Pacific Islands Fisheries Science Center

Status of the Hawaiian Bottomfish Stocks, 2004

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Robert B. Moffitt, Donald R. Kobayashi, and Gerard T. DiNardo

May 2006

Administrative Report H-06-01

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For further information direct inquiries to

Chief, Scientific Information Services
Pacific Islands Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce
2570 Dole Street
Honolulu, Hawaii 96822-2396

Phone: 808-983-5386
Fax: 808-983-2902

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PREFACE

Scientists of the Pacific Islands Fisheries Science Center (PIFSC) have assessed the status of deep-slope bottomfish in the Hawaiian Archipelago since the early 1980s. The current report describes the status of bottomfish in 2004 based on an assessment conducted by PIFSC in late 2005. The assessment used the best data and biological information available in 2005, and the same stock assessment methodology was employed as in other recent bottomfish assessments by the PIFSC.

An important objective of PIFSC research is to continuously improve stock assessment methods to take into account new information and more realistic biological parameters. Accordingly, during May 1 – 12, 2006, PIFSC convened the Hawaiian Archipelago Bottomfish Stock Assessment Workshop. The workshop brought together PIFSC scientists and a panel of stock assessment experts from the University of British Columbia. The panel was contracted by PIFSC to critically review the Center's current bottomfish assessment procedures, devise improved methods, use the revised approach to conduct a new bottomfish stock assessment, and recommend steps the Center could take to advance deep-slope bottomfish assessments in the Hawaiian Archipelago. The panel's contract report, including the new stock assessment, is expected later this year. PIFSC will publish the panel's findings when they become available.

INTRODUCTION

There are two distinct bottomfish resources in the Hawaiian Islands: seamount groundfish and deep-slope bottomfish. The seamount resource includes alfonsin, *Beryx splendens*, and armorhead, *Pseudopentaceros wheeleri*. The deep-slope bottomfish resource is made up of several species (Table 1). Both resources are managed under the Bottomfish and Seamount Groundfish Fishery Management Plan (FMP) developed by the Western Pacific Regional Fishery Management Council (Council).

Within the U.S. Exclusive Economic Zone (EEZ), the seamount groundfish resource occurs only on Southeast Hancock Seamount located 1400 nm northwest of Honolulu. The stocks of alfonsin and armorhead on Southeast Hancock are part of a larger resource extending northwest along the Emperor Seamount chain in international waters. A trawl fishery for seamount groundfish was started by Russian and Japanese fleets in the late 1960s, and large catches of armorhead were taken for about 10 years until the fishery crashed (Uchida and Tagami, 1984). The resource has never been harvested by U.S. vessels. Based on Council recommendations, a moratorium on fishing within the U.S. EEZ began in 1986 and continues through the present as no substantial recovery in the resource has been observed.

The Hawaii fishery for deep-slope bottomfish in the Hawaiian Archipelago has been in existence since the turn of the 20th century and quite likely well before then (Haight et al., 1993). Currently, participants in the fishery are a complex mix of subsistence, recreational, and commercial fishermen. The fishery primarily involves seven species of eteline snappers and a grouper caught at depths of 30–150 fathoms by small boats using hook-and-line gear. The fishery has very little bycatch of unwanted finfish, negligible impact to the deep-slope ecosystem (Kelley and Ikehara, in press), and negligible interactions with protected species (Kobayashi and Kawamoto, 1995).

For management purposes, the Hawaiian Archipelago is divided into three management zones (Fig. 1). In the main Hawaiian Islands (MHI), the bottomfish fishery is primarily under State of Hawaii jurisdiction and supports many subsistence, recreational, and commercial fishermen (about 300 commercial fishermen in 2004) In the Northwestern Hawaiian Islands (NWHI), the fishery is primarily under Federal jurisdiction and the fishing area is further divided into two management zones, the Mau Zone and the Ho'omalu Zone, each supporting limited-entry commercial fisheries (four permitted vessels operated in the Ho'omalu Zone and five in the Mau Zone in 2004) and little noncommercial fishing.

In this document we report the status of deep-slope bottomfish stocks in the Hawaiian Archipelago relative to established management metrics (Moffitt and Kobayashi, 2000). The report also describes the data used to assess the stock status, including fishery dependent and biological data. For assessment purposes, the Hawaiian bottomfish stocks are considered a single, archipelago-wide, multispecies complex (Moffitt and Kobayashi, 2000).

DATA SOURCES

Commercial Catch, Effort, and Sales

Most of the data used to assess the Hawaiian bottomfish stocks are derived from commercial catch information collected by the State of Hawaii. Since 1948, the State has required commercial fishermen to report their sales of any fish, including bottomfish species (Table 2). The quality and quantity of the data collected have varied over the years; more complete and better quality data have been collected in recent years. The original intent of the State's data collection system was to record economic information, not to gather data for stock assessment purposes. Data included commercial license number, date, gear type, area fished, species, number of fish sold (by species), weight of fish sold, and sale price. Some confusion exists as to whether the "date" information submitted reflects dates when fish were sold or dates when they were caught (as requested), particularly in the earlier data. Also, information on duration of fishing trips was not requested in the earlier period, so accurate estimation of nominal effort is difficult at best.

In 1984, the National Marine Fisheries Service (NMFS) began interviewing NWHI fishermen and obtained information on the number of days fished on each trip. This information, coupled with the Hawaiian Division of Aquatic Resources (HDAR) sales data, allowed for estimation of bottomfish catch-per-unit-effort (CPUE) in terms of catch per day (Kawamoto and Pooley, 1990). From 1994 onwards, the NWHI fishermen were required to provide a more detailed report to the State including their daily catch of each species, in number of fish, along with an estimated catch weight. This information, along with the more accurate fish weight data obtained from fish dealers, allows for calculations of catch per day in the absence of fisherman interviews. Additional data collected since 1996 on the number of fishing lines used each day has allowed for the calculation of CPUE in terms of catch-per-line hour. Beginning in 2002, similar daily data have been required from MHI commercial fishermen.

In addition to fisheries statistics reported by fishermen, observations on the commercial fishery have been made by employees or contractors of the State of Hawaii and NMFS staff. The State funded a series of charters of bottomfish vessels in 1981–1982. The NMFS Southwest Regional Office placed scientific observers on bottomfish vessels during 1990–1993; since October 2003, the NMFS Pacific Islands Regional Office (PIRO) has placed observers on approximately 25% of commercial bottomfishing trips. Observer data are not routinely used in the stock assessments but have been used to calibrate fishing effort in earlier production modeling analyses.

Noncommercial Catch

Information about noncommercial catch (subsistence and recreational) is scarce and of questionable value. Noncommercial marine fishing activities in Hawaii are not subject to licensing or reporting requirements. It is assumed that noncommercial landings in the NWHI

are negligible. This is not true for the MHI. In 1998, the State of Hawaii enacted bottomfish regulations that included a registration requirement for all bottomfishing vessels, including commercial, part-time commercial, and noncommercial boats. The program has registered more than 3500 vessels in the MHI. However, not all of these vessels are used for bottomfishing. Many boat owners registered their vessels to reserve the option to conduct bottomfishing operations. The noncommercial catches of bottomfish vessels remain unreported. However, in late summer 2005, a survey was sent to registered bottomfish vessel owners asking about their bottomfishing activity within the previous year. An analysis of this survey is underway and the results should provide a rough idea of the magnitude of noncommercial bottomfish landings.

Two other programs provide some insight into the MHI noncommercial catch. In the 1980s, the Hawaii Small-Boat Fisheries Survey (Hamm and Lum, 1992) was conducted, and since 2002, the Hawaii Marine Recreational Fishing Survey (HMRFS) has been in operation but has not had complete coverage of the bottomfish fishery in the MHI. Considering that regional and temporal patterns in noncommercial fishing activity are likely, it is not possible to calculate a time series of total bottomfish catch in the archipelago. Any estimates of total catch, or even landings, for the archipelago as a whole remain questionable.

Biological Data

In addition to commercial catch and sales data, certain biological information is used in our stock assessment, including size-at-maturity information reported in the literature (Everson, 1984; Everson, 1992; Everson et al., 1989; Kikkawa, 1984; Sudekum et al., 1991). This information is coupled with the mean catch weight data by species to obtain an estimate of the percentage of the catch made up of immature fish for each species. The literature includes much additional biological data, including information on bottomfish growth, diet, morphometrics, behavior, and other topics, but these data are not directly used in the assessment.

LANDINGS

Total adjusted commercial landings of Bottomfish Management Unit Species (BMUS), as defined in the FMP (WPRFMC, 1986), are shown in Tables 3–6 and Figures 2a and 2b. Results are given for the archipelagic stock as a whole and each of the three management areas separately Corrections were made to the fishermen's catch reports by comparing their landings to corresponding dealer reports, which contain more reliable weights. Further adjustment to the data on the three ulua (jack) species were achieved by allotting the catch of unidentified ulua amongst these species. The ulua adjustment factors were derived from data collected in recent years, for which identifications are generally quite good, and then applied to the entire data series.

Noncommercial landings are unreported in Hawaii as indicated earlier. Hamm and Lum (1992) estimated that the MHI noncommercial bottomfish catch during 1990–1991 was about

twice as much as the commercial landings, but they thought that noncommercial catch in the NWHI was negligible. The lack of data on noncommercial catch is a major concern.

In all management zones, reported commercial catches were relatively high in the late 1940s and early 1950s and again in the mid-to-late 1980s. Polovina et al. (1994) showed that the 1980s was a period of high productivity for lobster, seabirds, and other species in Hawaiian waters and attributed these changes to a decadal shift in oceanographic conditions. If similar enhancements also occurred in bottomfish stock productivity, they may have contributed to the increased landings and CPUE fluctuations reported during this period.

CATCH-PER-UNIT-EFFORT (CPUE)

Because the quality and precision of CPUE data have varied so much over the years, such data are provided here in several formats. The longest time series for CPUE are expressed in terms of catch per trip. For this series, the number of trips is inferred from the data on reported dates. In the MHI each reported date is assumed to represent a single trip of unknown duration, but likely to be 1 day. Fishing grounds in the MHI are near ports and markets, allowing fishers to catch and sell fish on a daily basis. For CPUE standardization purposes, MHI trips were screened to include only those from Maui, Lanai, Molokai, and Penguin Banks for which at least 90% of landings were BMUS. Additionally, calculations were restricted to fishers whose annual landings were at least 30% of the median annual landings of the top 10 producers (in aggregated bottomfish weight). This filtering reduced temporal variation in average fishing power caused by the occasional entry and exit of low-producing vessels. Table 7 provides the MHI standardized catch per trip with bootstrapped 95% confidence limits. Point values of CPUE are shown in Figure 3.

For early NWHI data, consecutive dates in a vessel's records most likely represent dates of sale, rather than dates of catch, and such records are aggregated to make a single trip of unknown duration. Fishing grounds in the NWHI zones are distant from ports and markets, resulting in at least a 3-day interval between fishing days on separate trips. Trips to the NWHI are often 1–2 weeks in duration. Table 8 provides Mau Zone catch per trip with bootstrapped 95% confidence limits, and Table 9 provides results for the Ho'omalu Zone. Point values are given in Figure 4.

Catch-per-unit-effort can also be estimated on a per day basis for the NWHI fisheries. Such data have been collected for both NWHI management zones since 1988. The data are derived from a combination of interviews and catch reports (in recent years the catch report data have been sufficient and interviews have not been conducted). Table 10 and Figure 5 show catch-per-day estimates for the Mau and Ho'omalu Zones.

MEAN WEIGHT AND PERCENT IMMATURE IN THE CATCH

Mean weights of bottomfish caught in the MHI and NWHI are computed annually. Prior to 2000, fish-size data were derived from auction lot statistics obtained at the United Fishing Agency auction in Honolulu by HDAR, NMFS, and WPRFMC personnel (Ralston and

Kawamoto, 1985). Since 2000, size data have been obtained from the State of Hawaii Dealer Reports. For each lot of fish sold, these data sets record the number of fish and their aggregate weight. Weight statistics for individual fish are not routinely collected; however, analysis of bottomfish size variation in auction lots indicated that reliable size frequency distributions could be derived from the lot data (Ralston et al. 1986). Table 11 and Figure 6 display the annual mean weights of Hawaii bottomfish caught in the three management zones for the primary species.

Estimates of the percentage of the catch composed of immature fish were calculated in terms of weight and computed from size data aggregated by year and management zone. The size distribution of sold fish was assumed to be representative of all fish caught. Maturity was assumed to be "knife-edge," and all fish in the same sales lot were assumed to be of equal size (mean weight for the lot). The sizes at maturity for these species were based on the scientific literature (Everson, 1984; Everson, 1992; Everson et al., 1989; Kikkawa, 1984; Sudekum et al., 1991). Estimates of the percentages of catch made up of immature fish are presented in Table 12 and Figure 7.

The average mean weight of bottomfish caught in the MHI is less than in the NWHI, for all species (Table 11, Fig. 6). In exploited fish populations, mean fish size generally declines as fishing mortality increases. The smaller mean size of the BMUS in the MHI indicates that MHI fishing mortality is much greater than in either NWHI zone. The reverse relationship holds for the percentage of immature fish in the exploited stock. This parameter typically increases with fishing pressure, and the average proportion of immature fish has been higher in the MHI than in the NWHI (Table 12, Fig. 7). Prior to 2004, the percentage of the catch consisting of immature fish was used as one of the indicators of stock health with a threshold level of 50%. Particular care is needed when this level is surpassed to ensure that the spawning population remains large enough to support adequate recruitment. In Hawaii, the 50% threshold is exceeded only for onaga, and this is seen to occur both in the MHI, where fishing pressure is intense, and the NWHI, where fishing pressure is relatively light. The threshold is exceeded even for low exploitation levels because onaga has a large size at first maturity (approx. 10 lbs) Thus, for onaga, a close monitoring of the spawning potential ratio (SPR) is required to ensure that the spawning population is not dropping below critical levels.

SPAWNING POTENTIAL RATIO

Prior to 2004, the spawning potential ratio (SPR) was the primary metric for determining the status of the bottomfish stocks and the only one used in defining an overfished condition (WPRFMC, 2004). Other metrics, such as CPUE and the percentage of catch made up of immature fish, were used in determining warning levels only. By FMP definition, when SPR dropped below 0.20 for any BMUS, that species was considered overfished. This definition was superceded in 2004 (see later section in this report).

Although no longer used to judge whether a stock is overfished under the FMP, SPRs are still calculated and monitored for Hawaiian BMUS and incorporated in the control rules as a species-specific, secondary layer of precaution. SPR for each species is calculated as the product of two ratios:

$$SPR = (CPUE_{current} / CPUE_{virgin}) \times (\%\ Mature_{current} / \%\ Mature_{virgin}) \times 100.$$

The CPUE values shown in Tables 7–10 are for the multispecies bottomfish stock as a whole and do not reflect well the abundance of any particular component species. For this reason, additional series of species-specific CPUE values are calculated where possible. In the NWHI, methods to estimate species-specific CPUE values have not yet been developed. Fishing trips in these zones are multiday and a single trip can target a range of species. For the MHI, however, species-specific CPUE values (targeted CPUEs) can be estimated. To calculate targeted CPUEs, we screen the catch data to include only trips on which at least 50% of the catch is of the targeted species and use only these trips to calculate CPUE. Targeted CPUE values for opakapaka, onaga, ehu, and uku were calculated. Targeted trips for other species were either not present or infrequent in the data. Partial CPUE values, computed by dividing the landings for each species by the total effort for the entire complex, were used in the above equation if targeted CPUE values could not be estimated.

SPR contribution values are calculated for each management zone separately, then these are combined into an archipelagic value in an additive fashion using management zone weighting factors (Wt) based on the relative length of the 100-fathom contour within the zone:

$$SPR_{Archipelago} = (SPR_{MHI} \times Wt_{MHI)} + (SPR_{Mau} \times Wt_{Mau}) + (SPR_{Ho'omalu} \times Wt_{Ho'omalu})$$

The positive weighting factors add up to 1.0. Table 13 displays archipelagic estimates of SPR for each of the five major BMUS species: opakapaka, onaga, ehu, uku, and hapu'upu'u.

DYNAMIC PRODUCTION MODEL

For this assessment, a dynamic production model was applied to time series of bottomfish catch and effort data for the three management zones of the Hawaiian Archipelago. In the Ho'omalu Zone and Mau Zone, the analysis involved commercial fishery data (catch-per-day) from vessel logbooks and interview data (1988–2004). In the MHI, only the State of Hawaii commercial catch data for the 1948–2004 period were used.

A simplified three-parameter dynamic production model was fit simultaneously to the three time series of catch data by nonlinear regression. The model used is similar to the one described by Kobayashi (1996). This approach reduces the number of fitted parameters by using outside information for some parameters and incorporating some shared parameters where applicable. It has been shown to be a useful approach for short time series involving geographically separate regions thought to have similar biological dynamics (Polovina, 1989). The basic equation for the dynamic production model is from Hilborn and Walters (1992) with a slight modification to the catch formula which prevents catch from exceeding population size at high levels of exploitation (Dr. Richard B. Deriso, Inter-American Tropical Tuna Commission, pers. comm.):

$$\hat{B}_t = \hat{B}_{t-1} + r\,\hat{B}_{t-1}\left(1 - \frac{\hat{B}_{t-1}}{k}\right) - C_{t-1}$$

$$\hat{C}_t = \hat{B}_t\left(1 - e^{-qE_t}\right)$$

$$B_{\text{initial}} = \frac{\text{Average of first 3 years CPUE}}{q}$$

where:

t = time in units of years,

$\hat{B}_t$ = modeled biomass at time t in units of pounds,

$\hat{B}_{t-1}$ = modeled biomass at time t-1 in units of pounds,

r = the intrinsic rate of population increase,

k = the population carrying capacity in units of pounds,

C_{t-1} = the observed catch at time t-1 in units of pounds,

$\hat{C}_t$ = the predicted catch at time t in units of pounds,

q = the catchability coefficient in units of per day,

E_t = the fishing effort at time t in units of days,

B_{initial} = the starting biomass for the time series in units of pounds,

CPUE = the catch-per-unit-of-effort in units of pounds per day with MHI trips assumed to be 1 day in duration for this application.

For each management zone, zonal maximum sustainable yield (MSY) contribution (ZMC) reference points for the bottomfish fishery are calculated separately, incorporating zone-specific estimates of k as:

$$ZMC = \frac{rk}{4},\quad B_{\text{ZMC}} = \frac{k}{2},\quad E_{\text{ZMC}} = \frac{r}{2q},\quad \text{and}\quad \text{CPUE}_{\text{ZMC}} = \frac{2qk}{4}$$

where:

ZMC = the maximum long-term sustainable catch contribution in units of pounds,

B_{ZMC} = the population biomass at ZMC in units of pounds,

E_{ZMC} = the fishing effort at ZMC in units of days, and

CPUE_{ZMC} = the catch-per-unit-of-effort at ZMC in units of pounds per day.

The GRG2 nonlinear least squares algorithm in Excel Solver was used to minimize the sum of squared deviations between C_t and $\hat{C}_t$. The three parameters to be estimated were the intrinsic rate of population increase (r, shared by all three regions), the Mau Zone population carrying capacity (k, with values for the Ho'omalu Zone and MHI scaled by zone-specific bottomfish habitat multipliers), and an initial value of MHI catchability (q). Given the longer history of the MHI fishery (i.e., 50 + years), catchability in the MHI was assumed to follow a four-level step function describing increases in fishing power (skill, technology, etc.) over time (prior to 1967, $q = 0.000166$; 1967 – 1984, $q = 0.000190$; 1985 – 1991, $q = 0.000238$; 1992 – present, $q = 0.000285$). Catchabilities in the NWHI zones were assumed fixed over time and were estimated from bottomfish depletion studies in the Western Pacific as described in Kobayashi (1996). Results of the analysis are presented in Table 14 and Figure 8.

STOCK STATUS

National Standard 1 of the Sustainable Fisheries Act (SFA) requires that federally managed fish stocks be maintained at levels of abundance that would allow for long-term maximum sustainable yields (MSY). The SFA requires that reference points (thresholds) be defined to determine whether the stock is being "overfished" and whether "overfishing" is occurring. Overfishing is determined to occur when current fishing mortality (F) is higher than the level at which MSY is produced. Similarly, stocks are determined to be overfished when current stock biomass (B) is below the level supporting MSY.

In 2000, Moffitt and Kobayashi (2000) defined new criteria to determine whether a BMUS stock was overfished or whether overfishing was occurring, following the guidelines set forth in National Standard 1 (Restrepo et al., 1998). In 2004, these criteria were accepted by the Secretary of Commerce (Amendment 6 to the FMP). These definitions were applied to the archipelago multispecies bottomfish stock, rather than individual species stocks, under an option allowed by the Sustainable Fisheries Act. Available scientific evidence (from computer simulation and tagging studies) suggests that bottomfish metapopulations are connected via egg/larval stages and potential movement of adults between banks (PIFSC and State of Hawaii, unpublished).

Under the accepted rules, each year the current ratios of F/F_{MSY} and B/B_{MSY} are calculated for the archipelago-wide stock as a whole. Management action is mandated when either of the resulting ratios violates a defined threshold. Together these two ratios determine the status of the archipelagic multispecies stock. As mentioned above, SPR, although not the primary measure of stock status, is also calculated for individual species and evaluated along with the established 20% reference points. SPR criteria provide a second level of precautionary evaluation.

The fitted dynamic production model discussed above is used to establish MSY reference values for biomass (B_{MSY}) and fishing mortality (F_{MSY}). The ratios of current values to these reference values then determine the status of fishing mortality and stock biomass within the control rules:

$$B_{status} = B_{Current} / B_{MSY}$$

and

$$F_{status} = F_{Current} / F_{MSY}$$

Using CPUE as a proxy for B and effort (E) as a proxy for F, the current biomass and fishing mortality metrics for the three management zones were calculated in a similar fashion, substituting the appropriate zonal MSY contribution (ZMC) reference points (Table 15):

$$B_\text{metric} = \text{CPUE}_{Current} / \text{CPUE}_{ZMC}$$

and

$$F_\text{metric} = E_{Current} / E_{ZMC}$$

Archipelago stock status values (Table 16 and Fig. 9) for both biomass and fishing mortality metrics were derived as weighted averages of values for the three management zones:

$$B_\text{status}_{Archipelago} = (B_\text{metric}_{MHI} \times \text{Wt}_{MHI}) + (\text{B_metric}_{Mau} \times \text{Wt}_{Mau}) + (\text{B}_{Ho'omalu} \times \text{Wt}_{Ho'omalu}) + (\text{B_metric}_{Ho'omalu} \times \text{Wt}_{Ho'omalu})$$

and

$$F_\text{status}_{Archipelago} = (F_\text{metric}_{MHI} \times \text{Wt}_{MHI}) + (F_\text{metric}_{Mau} \times \text{Wt}_{Mau}) + (F_\text{metric}_{Ho'omalu} \times \text{Wt}_{Ho'omalu}) + (F_\text{metric}_{Ho'omalu} \times \text{Wt}_{Ho'omalu})$$

Weighting factors (MHI = 0.447, Mau = 0.124, Ho'omalu = 0.429) are based on the relative area of habitat (100-fathom contour) in each of the zones (PIFSC, unpublished).

Biomass and fishing mortality metrics for the three management zones are used as metrics to evaluate alternative management strategies. If the archipelagic stock as a whole is determined to be overfished or experiencing overfishing, area-specific metrics can be evaluated by managers to identify where the problems may arise (MHI, Mau, or Ho'omalu Zones) so that effective management measures can be applied. In the context of the area-specific management analysis, the terms "overfishing" and "overfished" are sometimes used to refer to conditions of excessive fishing pressure and depleted biomass within a management zone; however, as official descriptors of stock status under the Magnuson-Stevens Fishery Conservation and Mangement Act (MSFCMA) they are applied on an archipelago-wide basis only.

The control rule was first applied to the Hawaii bottomfish stock in the 2003 Bottomfish and Seamount Groundfish Annual Report (WPRFMC, 2004) using data through 2002. In the analysis for this more current assessment, we updated the time series to include 2003 and 2004 data for both the dynamic production model reference values and status determinations. Additionally, we used the fitted model to back-calculate (hindcast) control rule criteria for data years 1988–2001 to evaluate changes in biomass and fishing mortality ratios over a longer time span. As can be seen (Table 16), archipelagic biomass and fishing mortality ra-

tios have both declined over this time period. According to the model hindcasts, the biomass ratio has remained above the control rule minimum stock size threshold (MSST) ratio of 0.70 throughout this time span, whereas the fishing mortality ratio, though improving recently, has exceeded the maximum fishing mortality threshold (MFMT) ratio of 1.00 every year since 1988.

The management zone metrics (Table 15) indicate that MHI fishing mortality metrics are well above those of the other two zones and that excessive fishing pressure in the MHI is the major contributor to overfishing in the archipelago. Since the archipelagic fishing mortality ratio exceeds the MFMT value of 1.0, corrective management measures are mandated. The management zone metrics clearly show excessive fishing pressure in the MHI Zone. Assuming management measures were applied solely to the MHI, an iterative computation using the dynamic production model indicates that the $F_\text{metric}_{\text{MHI}}$, and hence fishing effort, would have to be reduced from the 2004 level by 24% to bring archipelago-wide fishing mortality down to the MFMT of 1.00. A larger reduction would be needed to support a risk-averse management policy (e.g., choosing a target reference point less than the threshold reference point).

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Table 1. Principal species comprising the deep-slope bottomfish resource.

Common Name	Scientific Name
Onaga	*Etelis coruscans*
Opakapaka	*Pristipomoides filamentosus*
Ehu	*E. carbunculus*
Kalekale	*P. seiboldii*
Gindai	*P. zonatus*
Uku	*Aprion virescens*
Lehi	*Aphareus rutilans*
Yellowtail kalekale	*P. auricilla*
Hapu'upu'u	*Ephinephelus quernus*
Butaguchi	*Pseudocaranx dentex*
White ulua	*Caranx ignobilis*
Black ulua	*C. lugubris*
Kahala	*Seriola dumerili*
Taape	*Lutjanus kasmira*

Table 2. Data needs, sources, availability, and applicability.

Data Needs	Sources	Availability	Applicability
Catch and Effort	State of Hawaii Commercial Catch Reports	1948–present	• Effort determination limited to inferred trips of unknown duration. • Reports commercial landings only. • Accuracy and comprehensiveness of data unknown, but thought to have improved over time.
	NMFS Fisherman Interviews and NWHI Log Books	1984–present	• Provides good data on trip duration allowing calculation of CPUE in terms of pounds per day. • Complete coverage. • Assumes no noncommercial catch in NWHI.
Weight	Catch Reports, Sales Reports and Dealer Data	1948–present	• Catch reports provide data since 1948, but accuracy and comprehensiveness unknown. • Dealer data available since 1980s are accurate, but not comprehensive. • Dealer reports available since 2000 provide complete data.

Table 3. Total reported archipelagic catch of BMUS (in pounds). Data sources are indicated in Table 2.

Year	Opakapaka	Onaga	Ehu	Hapu'upu'u	Uku	Gindai	Kalekale	Taape
1948	231,134	52,793	109,691	85,194	103,386	285	32,596	
1949	257,278	80,113	119,907	70,024	86,872	298	37,054	
1950	235,366	82,014	85,396	81,767	68,564	2,322	33,572	
1951	262,799	56,768	61,441	68,583	49,969	3,833	42,964	
1952	316,519	46,274	57,623	98,892	72,621	3,601	35,785	
1953	233,771	58,925	49,647	77,193	81,234	2,904	38,562	
1954	150,128	67,875	33,745	41,929	68,854	2,730	33,323	
1955	181,367	64,535	39,175	68,281	82,417	5,870	33,930	
1956	155,556	89,548	50,100	44,867	83,753	3,681	35,008	
1957	127,026	61,988	32,385	32,249	101,017	2,270	20,638	
1958	122,157	64,458	24,293	28,512	74,304	2,061	20,191	
1959	88,090	49,745	23,317	31,844	46,173	1,424	21,931	
1960	89,494	40,852	17,977	22,367	45,475	1,078	16,309	
1961	93,171	42,982	12,822	20,526	42,309	694	19,090	
1962	104,425	62,585	23,588	22,957	63,811	889	18,294	
1963	121,118	53,919	28,066	32,718	65,069	2,314	24,325	
1964	105,860	57,543	23,312	24,164	89,896	1,612	16,081	
1965	83,247	65,890	19,856	21,207	50,433	468	14,010	
1966	97,536	69,735	19,587	33,098	58,117	1,019	13,072	
1967	110,149	58,114	16,046	23,396	58,645	664	7,034	
1968	90,817	69,946	22,886	21,135	49,862	757	5,124	
1969	89,489	48,454	16,636	21,207	57,582	1,363	5,648	
1970	52,835	38,191	16,688	40,473	49,276	1,683	4,466	1,116
1971	82,427	47,954	21,865	49,569	49,005	2,063	6,967	2,211
1972	118,135	50,295	30,234	36,916	52,227	1,933	7,108	3,544
1973	132,072	42,670	22,047	50,794	69,206	2,599	6,464	6,081
1974	111,621	40,526	26,803	39,439	82,665	1,544	5,813	6,298
1975	161,558	66,204	31,976	59,808	62,430	1,963	8,862	20,744
1976	121,848	90,602	35,714	58,389	63,383	1,520	9,186	29,523
1977	150,898	67,348	31,687	49,143	72,483	1,772	7,345	36,127
1978	176,635	62,377	35,314	74,494	85,808	3,703	9,800	59,093
1979	205,398	48,782	21,819	64,949	87,921	3,579	8,303	61,687
1980	230,805	34,307	18,363	55,121	74,964	2,358	7,079	61,747
1981	191,079	54,906	22,104	30,979	85,124	1,696	7,265	81,284
1982	201,120	62,664	25,555	45,489	100,992	2,070	10,440	59,284
1983	226,222	103,481	39,159	45,048	140,369	4,148	16,400	62,271
1984	349,897	115,739	37,261	59,342	147,426	4,882	18,447	42,476
1985	303,518	239,535	69,100	98,889	54,731	7,183	28,672	59,600
1986	305,227	239,551	60,273	103,457	106,512	5,251	23,334	53,485
1987	411,623	196,339	54,636	75,141	57,991	4,951	29,833	49,561
1988	352,201	157,079	50,885	33,874	347,767	2,690	12,364	44,401
1989	372,563	165,151	48,074	67,283	213,346	2,975	14,639	43,652
1990	216,404	126,852	54,100	64,560	168,449	6,023	24,431	52,177
1991	217,021	128,654	46,889	66,032	151,033	6,766	25,318	66,698
1992	256,520	87,564	35,692	56,016	131,517	5,770	27,969	67,127
1993	296,283	102,176	33,372	66,650	101,236	7,338	18,650	62,666
1994	323,538	102,015	37,488	79,339	146,180	8,764	27,615	60,194
1995	277,465	123,515	39,993	69,293	136,752	6,613	24,797	71,929
1996	228,644	98,476	47,559	58,067	117,671	9,215	31,483	44,235
1997	257,858	124,742	41,469	72,554	107,475	8,161	29,793	85,506
1998	227,025	110,011	41,807	84,190	116,340	8,594	25,334	74,853
1999	208,920	159,544	37,830	71,901	130,736	6,372	15,818	70,078
2000	206,784	169,342	43,119	41,435	122,867	5,646	20,932	55,058
2001	157,086	129,447	35,394	36,478	113,690	5,174	15,369	47,598
2002	145,918	124,414	27,733	38,008	116,828	5,067	15,173	37,893
2003	132,524	120,000	24,733	46,712	136,084	4,759	11,722	31,046
2004	133,189	155,997	31,912	42,214	150,237	5,315	9,506	42,389

Table 3 (continued). Total reported archipelagic catch of BMUS (in pounds).

Year	Yellowtail Kalekale	Lehi	Kahala	Butaguchi	White Ulua	Black Ulua	Armorhead	Total BMUS
1948		17,216	193,231	152,710	62,720	2,727		1,043,684
1949		6,044	213,479	123,321	50,650	2,202		1,047,242
1950		3,193	155,409	109,007	44,771	1,947		903,327
1951		6,932	166,565	94,703	38,896	1,691		855,144
1952		6,450	176,931	137,637	56,529	2,458		1,011,320
1953		3,500	99,000	175,658	72,145	3,137		895,676
1954		1,941	69,730	123,049	50,538	2,197		646,039
1955		2,120	83,631	103,598	42,549	1,850		709,324
1956		8,879	60,149	55,617	22,843	993		610,994
1957		3,087	70,128	54,125	22,230	967		528,109
1958		3,365	90,012	48,950	20,105	874		499,282
1959		1,179	79,098	30,854	12,672	551		386,878
1960		1,177	86,204	52,912	21,732	945		396,522
1961		1,431	76,607	38,568	15,840	689		364,729
1962		2,048	86,467	39,644	16,282	708		441,698
1963		2,295	105,698	49,935	20,509	892		506,858
1964		989	95,916	60,805	24,974	1,086		502,238
1965		1,382	74,987	42,246	17,351	754		391,832
1966		2,362	99,084	36,268	14,896	648		445,422
1967		2,604	69,494	43,588	17,902	778		408,415
1968		4,014	87,247	213,144	87,541	3,806		656,280
1969		4,722	72,463	53,546	21,992	956		394,058
1970		1,342	70,157	36,262	14,893	648		328,029
1971		2,128	83,361	34,320	14,096	613		396,578
1972		5,056	56,992	24,930	10,239	445		398,054
1973		6,489	66,119	27,135	11,145	485		443,305
1974		4,376	34,122	35,269	14,485	630		403,591
1975		10,558	30,177	58,358	23,969	1,042		537,649
1976		9,540	41,023	55,397	22,753	989		539,867
1977		8,979	57,361	43,770	17,977	782		545,671
1978		10,221	99,095	68,511	28,138	1,223		714,413
1979		16,440	83,662	53,328	21,902	952		678,722
1980		17,247	49,728	89,480	36,751	1,598		679,547
1981		26,197	38,149	56,043	26,105	938		621,869
1982		28,711	73,741	63,627	51,514	925		726,132
1983		23,682	103,920	64,481	40,598	1,069		870,849
1984		21,581	85,017	79,910	45,362	1,167		1,008,507
1985		30,871	40,574	81,196	45,150	2,682		1,061,701
1986		23,056	38,494	104,700	32,098	1,101		1,096,539
1987		37,744	19,933	115,468	33,066	1,910		1,088,196
1988		50,952	42,502	90,682	57,376	1,772		1,244,545
1989		43,622	36,120	127,972	66,486	1,768		1,203,651
1990		21,598	20,347	121,283	35,019	1,485		912,728
1991		12,925	12,262	99,689	26,961	1,100	31	861,379
1992		18,100	10,352	88,133	30,624	778		816,162
1993		10,279	5,658	82,795	16,077	1,350		804,529
1994		11,237	18,843	86,045	21,707	853		923,819
1995		14,716	15,545	82,476	21,244	1,696		886,035
1996	49	9,072	5,761	73,755	27,446	1,369		752,802
1997		12,467	12,156	82,870	17,671	1,297		854,019
1998	25	8,690	22,285	63,763	19,901	1,212	12	804,041
1999	6	9,895	18,905	45,857	11,646	512	11	788,031
2000		11,413	24,597	51,537	11,467	892	8	765,098
2001	5	10,452	14,530	43,431	15,657	670		624,980
2002	7	9,380	12,621	43,661	12,575	1,802		591,080
2003	8	8,864	5,634	25,804	11,340	1,482		560,713
2004	55	6,552	10,386	26,814	11,984	1,374	4	627,927

Table 4. Total reported catch of BMUS in the MHI (in pounds). Data sources are indicated in Table 2.

Year	Opakapaka	Onaga	Ehu	Hapu'upu'u	Uku	Gindai	Kalekale	Taape
1948	120,891	50,637	103,415	23,350	101,573	285	32,244	
1949	133,167	77,630	106,140	29,536	83,918	298	36,432	
1950	122,616	75,398	71,298	14,595	57,898	1,328	31,815	
1951	106,428	53,018	49,699	22,000	45,091	2,621	41,165	
1952	112,980	44,604	53,810	27,525	64,847	2,592	33,392	
1953	112,509	57,361	46,358	19,952	72,418	1,687	38,275	
1954	89,012	67,583	32,324	13,367	61,957	2,003	33,176	
1955	82,152	63,228	36,069	25,912	76,067	3,932	32,312	
1956	137,169	76,025	43,410	19,339	70,761	2,679	34,122	
1957	106,743	59,218	30,157	14,788	96,442	1,754	19,921	
1958	111,356	63,774	22,310	18,333	72,517	1,863	18,951	
1959	62,138	49,745	23,107	15,294	46,040	1,344	21,688	
1960	61,272	33,158	16,962	8,418	45,426	790	15,943	
1961	70,610	42,701	12,370	6,642	42,200	592	19,019	
1962	85,407	62,355	22,893	12,584	63,700	665	17,952	
1963	109,414	53,225	25,282	12,865	63,562	2,040	23,916	
1964	94,121	47,766	20,918	9,391	89,858	1,501	15,862	
1965	81,043	65,040	17,605	10,297	49,485	464	13,978	
1966	92,850	69,634	19,342	13,277	57,849	1,012	13,055	
1967	106,954	58,111	15,606	9,153	58,556	616	6,994	
1968	89,908	69,922	21,984	11,287	49,677	641	5,098	
1969	88,621	48,454	16,517	18,300	57,542	1,319	5,628	
1970	49,658	37,894	13,364	13,651	47,443	856	3,702	1,116
1971	76,388	47,250	17,626	14,746	48,710	930	6,560	2,211
1972	117,367	49,213	20,347	18,994	48,077	1,330	6,222	3,544
1973	130,785	39,811	16,336	13,878	66,875	1,595	5,073	6,081
1974	107,908	38,883	21,015	18,874	77,961	1,142	4,863	6,298
1975	147,755	66,029	30,155	38,140	62,202	1,886	8,478	20,744
1976	111,520	89,518	33,788	28,214	62,165	1,520	9,137	29,523
1977	126,940	67,312	30,446	25,071	68,478	1,658	7,262	36,125
1978	138,931	62,208	34,333	33,271	83,798	3,191	9,713	59,091
1979	170,180	46,271	20,339	23,538	87,128	2,799	8,295	61,687
1980	177,017	33,350	17,660	15,903	74,723	1,893	7,077	61,747
1981	183,953	54,609	21,422	17,271	85,084	1,442	7,255	81,284
1982	188,989	61,771	24,957	23,511	100,929	1,753	10,438	59,277
1983	208,691	103,099	38,870	40,416	132,548	4,006	16,274	62,249
1984	199,194	109,422	33,392	26,095	138,913	3,844	18,179	42,425
1985	174,817	218,614	56,070	29,055	49,307	4,346	25,872	57,145
1986	202,952	167,112	50,312	31,626	104,047	2,695	20,415	53,481
1987	274,929	171,450	46,025	13,232	56,753	2,935	28,589	49,502
1988	320,628	136,708	39,054	13,003	344,426	1,916	11,620	44,379
1989	275,887	158,548	40,581	13,075	208,354	2,092	14,286	43,614
1990	147,357	107,537	34,140	15,165	114,398	3,314	19,051	50,940
1991	134,334	89,015	27,039	14,234	90,367	4,236	19,367	66,690
1992	178,014	71,715	29,461	14,454	88,474	4,248	24,756	67,127
1993	143,673	62,861	23,102	11,313	69,966	3,877	14,906	62,652
1994	179,451	66,188	23,601	13,482	71,821	3,771	21,364	59,755
1995	174,261	73,471	28,574	16,141	62,473	3,896	19,902	71,844
1996	148,730	67,550	28,286	11,466	53,309	3,143	21,788	44,195
1997	145,807	69,145	25,798	14,215	67,976	2,812	21,252	85,491
1998	141,958	58,325	23,728	11,346	61,105	3,346	19,886	74,851
1999	129,155	60,981	19,429	10,106	89,834	2,390	11,190	70,073
2000	149,310	74,531	29,522	16,183	80,036	3,653	16,659	55,041
2001	100,003	54,993	20,911	11,105	57,469	3,127	11,759	47,551
2002	108,917	68,981	17,441	8,411	56,930	2,129	11,451	39,399
2003	115,719	71,560	15,489	10,208	44,254	2,039	9,922	37,895
2004	102,168	85,072	22,178	8,018	67,776	2,104	7,785	43,528

Table 4 (continued). Total reported catch of BMUS in the MHI (in pounds).

Year	Yellowtail Kalekale	Lehi	Kahala	Butaguchi	White Ulua	Black Ulua	Armorhead	Total BMUS
1948		17,183	167,317	33,314	55,116	1,804		707,129
1949		6,044	187,573	25,980	42,982	1,407		731,106
1950		3,175	114,848	21,087	34,886	1,142		550,086
1951		6,925	124,081	15,776	26,100	854		493,758
1952		6,249	97,228	16,396	27,126	888		487,637
1953		3,497	65,640	15,579	25,775	844		459,895
1954		1,926	51,411	11,396	18,853	617		383,625
1955		2,107	49,264	9,365	15,493	507		396,408
1956		8,879	50,626	11,024	18,238	597		472,869
1957		3,064	64,053	11,478	18,990	622		427,229
1958		3,365	86,473	9,981	16,513	541		425,976
1959		1,179	68,808	6,943	11,488	376		308,150
1960		1,177	79,576	8,040	13,302	435		284,500
1961		1,431	73,659	6,149	10,173	333		285,879
1962		2,048	81,620	7,772	12,858	421		370,274
1963		2,295	93,721	8,984	14,864	487		410,654
1964		989	86,113	8,776	14,519	475		390,289
1965		1,382	69,566	7,849	12,986	425		330,120
1966		2,362	92,288	8,903	14,729	482		385,782
1967		2,604	67,308	12,012	19,874	651		358,438
1968		4,014	84,215	66,559	110,118	3,605		517,028
1969		4,722	71,112	11,229	18,578	608		342,630
1970		1,342	57,350	7,444	12,316	403		246,539
1971		2,128	78,178	7,151	11,831	387		314,096
1972		5,056	52,152	7,733	12,795	419		343,249
1973		6,489	58,106	8,501	14,064	460		368,054
1974		4,376	31,762	9,883	16,350	535		339,850
1975		10,558	26,372	15,945	26,379	864		455,507
1976		9,540	36,377	16,455	27,223	891		455,871
1977		8,979	44,763	11,166	18,474	605		447,279
1978		10,219	73,519	15,576	25,770	844		550,464
1979		16,440	65,643	14,162	23,430	767		540,680
1980		17,225	44,415	16,223	26,840	879		494,952
1981		26,187	35,806	13,728	23,193	744		551,978
1982		28,711	72,326	18,105	32,050	863		623,680
1983		23,680	103,734	20,852	46,471	1,035		801,925
1984		21,579	84,945	19,382	47,975	1,008		746,353
1985		30,863	39,967	13,229	25,082	1,400		725,768
1986		23,056	38,405	29,857	32,009	927		756,894
1987		37,744	19,933	11,184	23,153	575		736,004
1988		50,390	42,502	24,270	52,802	1,341		1,083,039
1989		43,600	36,120	31,074	53,510	1,608		922,349
1990		21,285	20,347	20,998	35,124	794		590,450
1991		12,720	11,262	18,018	23,552	572		511,406
1992		17,572	10,352	13,627	25,935	710		546,445
1993		10,218	5,658	10,381	13,844	427		432,877
1994		11,020	11,849	11,601	14,144	544		488,591
1995		14,392	11,345	16,070	19,435	717		512,520
1996		8,839	5,526	9,798	17,028	406		420,063
1997		12,367	12,108	13,519	14,767	603		485,860
1998		8,647	21,805	9,286	15,864	713		450,859
1999		9,859	17,599	6,396	10,588	261		437,861
2000		10,834	22,573	6,954	11,161	306		476,763
2001	5	10,427	13,823	6,254	11,675	368		349,469
2002	1	9,536	11,336	5,306	10,240	623		350,701
2003	0	8,573	4,886	1,663	10,787	1,062		334,058
2004	44	6,673	6,952	1,580	11,429	1,052		366,358

Table 5. Total reported catch of BMUS in the Mau Zone (in pounds). Data sources are indicated in Table 2.

Year	Opakapaka	Onaga	Ehu	Hapu'upu'u	Uku	Gindai	Kalekale	Taape
1948	104,740	2,156	6,123	55,405	1,813	0	352	
1949	124,111	2,483	13,767	40,488	2,954		622	
1950	112,750	6,616	14,098	67,172	10,666	994	1,757	
1951	156,371	3,750	11,742	46,583	4,878	1,212	1,799	
1952	203,539	1,670	3,813	71,367	7,774	1,009	2,393	
1953	121,262	1,564	3,289	57,241	8,816	1,217	287	
1954	61,116	292	1,421	28,562	6,897	727	147	
1955	99,215	1,307	3,106	42,369	6,350	1,938	1,618	
1956	18,387	13,523	6,690	25,528	12,992	1,002	886	
1957	20,283	2,770	2,228	17,461	4,575	516	717	
1958	10,801	684	1,983	10,179	1,787	198	1,240	
1959	25,952		210	16,550	133	80	243	
1960	28,222	7,694	1,015	13,949	49	288	366	
1961	22,561	281	452	13,884	109	102	71	
1962	19,018	230	695	10,373	111	224	342	
1963	11,704	694	2,784	19,853	1,507	274	409	
1964	11,739	9,777	2,394	14,773	38	111	219	
1965	2,204	850	2,251	10,910	948	4	32	
1966	4,686	101	245	19,821	268	7	17	
1967	3,195	3	440	14,243	89	48	40	
1968	909	24	920	9,848	185	116	26	
1969	868		119	2,907	40	44	20	
1970	3,177	297	3,324	26,822	1,833	827	764	
1971	6,039	704	4,239	34,823	295	1,133	407	
1972	768	1,082	9,887	17,922	4,150	603	886	
1973	1,287	2,859	5,711	36,916	2,331	1,004	1,391	
1974	3,713	1,643	5,788	20,565	4,704	402	950	
1975	13,803	175	1,821	21,668	228	77	384	
1976	10,328	1,084	1,926	30,175	1,218		49	
1977	23,958	36	1,241	24,072	4,005	114	83	2
1978	37,704	169	981	41,223	2,010	512	87	2
1979	35,218	2,511	1,480	41,411	793	780	8	
1980	53,788	957	703	39,218	241	465	2	
1981	7,126	297	382	13,708	40	254	10	
1982	12,131	893	598	21,978	63	317	2	7
1983	17,531	382	289	4,632	7,821	142	126	22
1984	150,703	6,317	3,869	33,247	8,513	1,038	268	51
1985	128,701	20,921	13,030	69,834	5,424	2,837	2,800	2,455
1986	102,275	72,439	9,961	71,831	2,465	2,556	2,919	4
1987	136,694	24,889	8,611	61,909	1,238	2,016	1,244	59
1988	31,573	20,371	11,831	20,871	3,341	774	744	22
1989	96,676	6,603	7,493	54,208	4,992	883	353	38
1990	41,633	10,206	19,443	37,340	43,298	2,559	5,143	1,207
1991	12,111	9,171	15,670	16,151	23,287	1,479	5,171	2
1992	19,264	5,769	2,259	8,307	3,999	359	2,269	
1993	22,320	3,684	3,926	11,485	6,600	856	2,449	14
1994	18,845	9,432	7,643	14,365	51,822	2,524	3,141	381
1995	14,094	22,597	6,304	13,770	61,451	1,382	3,071	59
1996	15,632	10,865	12,238	20,166	47,610	3,487	7,729	40
1997	26,586	17,301	4,070	13,838	24,621	1,036	3,985	9
1998	9,524	1,835	3,091	7,517	32,152	613	1,630	2
1999	7,918	3,969	4,231	5,777	27,144	1,109	1,257	5
2000	6,987	3,462	5,159	4,657	13,033	841	2,638	17
2001	4,182	3,824	6,083	4,266	19,086	608	2,016	47
2002	15,402	9,723	6,698	17,103	45,273	1,399	3,097	24
2003	6,372	6,107	3,269	17,376	53,177	885	1,310	1
2004	10,603	9,570	2,491	11,822	46,767	913	869	5

Table 5 (continued). Total reported catch of BMUS in the Mau Zone (in pounds).

Year	Yellowtail Kalekale	Lehi	Kahala	Butaguchi	White Ulua	Black Ulua	Armorhead	Total BMUS
1948		33	23,201	54,672	6,703	1,489		256,687
1949			25,906	39,248	4,812	1,069		255,460
1950		18	40,561	35,691	4,376	972		295,671
1951		7	42,484	53,479	6,557	1,456		330,319
1952		201	79,703	72,256	8,860	1,967		454,552
1953		3	33,360	48,113	5,899	1,310		282,361
1954		15	18,319	30,046	3,684	818		152,044
1955		13	34,367	45,596	5,591	1,241		242,711
1956			9,523	1,747	214	48		90,540
1957		23	6,075	22,937	2,812	625		81,022
1958			3,539	3,055	375	83		33,923
1959			10,290	995	122	27		54,602
1960			6,628	13,811	1,693	376		74,092
1961			2,948	17,327	2,125	472		60,331
1962			4,847	22,646	2,777	617		61,880
1963			11,977	32,009	3,925	872		86,007
1964			9,803	37,142	4,554	1,011		91,561
1965			5,421	25,833	3,167	703		52,324
1966			6,796	12,963	1,589	353		46,847
1967			2,186	9,899	1,214	270		31,626
1968			3,032	14,574	1,787	397		31,818
1969			1,351	27,422	3,362	747		36,880
1970			12,807	19,263	2,362	525		72,001
1971			5,183	17,775	2,179	484		73,262
1972			4,840	1,928	236	52		42,354
1973			8,013	1,738	213	47		61,510
1974			2,360	7,305	896	199		48,524
1975			3,805	13,850	1,698	377		57,887
1976			4,646	7,441	912	203		57,982
1977			12,598	13,816	1,694	376		81,995
1978		2	25,576	27,469	3,368	748		139,851
1979			18,019	12,439	1,525	339		114,523
1980		22	5,313	5,269	646	143		106,768
1981		10	2,343	2,758	3,846	71		30,845
1982			1,415	211	26	6		37,646
1983		2	186	888	842	17		32,880
1984		2	72	9,039	163	38		213,320
1985		8	607	15,289	65	285		262,256
1986			89	10,210	233	156		275,138
1987				9,228	662	110		246,661
1988		562		4,648	64	336		95,137
1989		22		18,819	2,907	44		193,038
1990		295		46,994	340	605		209,063
1991		188	1,000	15,076	216	365		99,887
1992		334		10,666	0	23		53,249
1993		25		25,659	10	447		77,476
1994		141	5,271	36,269	995	259		151,088
1995		229	4,200	25,061	624	844		153,686
1996	49	201	205	25,301	819	872		145,215
1997		47		16,461	503	547		109,004
1998	25	43	480	9,123	238	450		66,723
1999	6	36	1,206	7,229	129	248		60,264
2000		575	2,024	14,397	302	184		54,276
2001	0	25	387	8,628	551	224		49,927
2002	6	26	1,285	10,387	784	1,169		112,376
2003	8	55	986	8,741	21	420		98,728
2004	11		1,518	11,555	140	282		96,547

Table 6. Total reported catch of BMUS in the Ho'omalu Zone (in pounds). Data sources are indicated in Table 2.

Year	Opakapaka	Onaga	Ehu	Hapu'upu'u	Uku	Gindai	Kalekale	Taape
1948	5,503		153	6,439			54	
1949	49,700	60	4,140	15,019	252		177	
1950	23,230	1,563	2,273	12,589	376	303	278	
1951	23,956	77	1,329	10,178	101	155	101	
1952	79,821	927	807	31,700	351	386	1,062	
1953	84,249	1,439	2,408	46,972	6,313	1,003	215	
1954	39,143	119,767	292	19,413	389	507	118	
1955	51,469	309	684	14,139	653	1,345	371	
1956	16,021	2,880	4,403	14,025	47	500	221	
1957	1,693	20	143	1,022	49	31	82	
1958	7,013	684	1,810	7,650		157	1,192	
1959	21,785		161	12,570	66	44	152	
1960	14,735	238	544	9,788	37	202	84	
1961	5,503		37	2,829	12	33	23	
1962								
1963								
1964								
1965	607	609	555	4,196	508	4	3,615	
1966								
1967								
1968								
1969								
1970								
1971								
1972								
1973								
1974								
1975								
1976								
1977	4,300							
1978	3,300			800				
1979	12,918	1,389	18	7,845		91		
1980	48,368	305	316	31,038	205	255		
1981	5,621	250	665	11,820	24	200	10	
1982	12,131	893	595	21,926		317	2	
1983	16,069	362	137	1,328	36	62	22	
1984	122,820	660	1,405	26,950	2,437	888	178	
1985	62,728	13,125	4,963	27,537	318	1,345	1,259	60
1986	91,649	59,419	6,141	53,566	1,323	1,916	1,461	4
1987	120,908	21,632	7,899	55,664	436	1,888	762	
1988	25,953	10,241	3,506	15,081	1,298	445	227	
1989	52,596	4,572	5,994	35,772	635	531	249	30
1990	39,289	10,429	806	18,395	12,653	196	529	
1991	70,137	30,458	4,169	35,624	37,279	1,041	780	
1992	54,605	9,987	3,806	31,821	38,705	1,025	860	
1993	130,105	35,343	6,238	43,837	6,238	2,593	1,238	
1994	124,571	26,144	5,432	51,455	22,526	2,096	1,911	
1995	88,933	27,289	4,785	39,319	12,821	1,237	1,719	
1996	62,784	19,909	6,261	24,318	16,377	2,464	1,708	
1997	85,465	38,296	11,230	44,490	14,853	4,289	3,913	
1998	75,537	49,851	14,988	65,313	23,040	4,501	3,710	
1999	71,841	94,594	14,161	56,018	13,758	2,860	3,201	
2000	50,487	91,354	8,487	20,595	29,824	1,153	1,563	
2001	52,901	70,630	8,372	21,107	36,491	1,362	1,499	0
2002	22,835	47,202	3,831	12,661	14,857	1,545	1,052	0
2003	15,960	48,379	7,579	19,800	41,721	1,982	1,149	0
2004	21,379	62,439	7,426	23,072	35,864	2,368	1,039	0

Table 6 (continued). Total reported catch of BMUS in the Ho'omalu Zone (in pounds).

Year	Yellowtail Kalekale	Lehi	Kahala	Butaguchi	White Ulua	Black Ulua	Armorhead	Total BMUS
1948			2,713	8,363	1,872	0		25,097
1949			12,991	22,746	5,091	60		110,236
1950			4,961	27,032	6,051	36		78,692
1951			5,438	12,337	2,762	19		56,453
1952		174	28,063	50,637	11,335	9		205,271
1953		3	25,204	130,102	29,122	26		327,057
1954		15	14,046	92,558	20,718	14		306,980
1955		13	17,949	59,245	13,261	25		159,463
1956			4,909	28,685	6,421	22		78,133
1957		20	597	4,111	920	4		8,693
1958			2,528	22,600	5,059	9		48,701
1959			7,732	12,405	2,777	6		57,697
1960			4,380	25,770	5,768	2		61,549
1961			744	10,513	2,353	0		22,047
1962				0	0	0		0
1963				0	0	0		0
1964				6,484	1,451	0		7,935
1965			3,615	168	38	0		13,915
1966				0	0	0		0
1967				0	0	0		0
1968				0	0	0		0
1969				0	0	0		0
1970				0	0	0		0
1971				0	0	0		0
1972				0	0	0		0
1973				0	0	0		0
1974				0	0	0		0
1975				0	0	0		0
1976				0	0	0		0
1977			120	0	0	0		4,420
1978				2,318	519	0		6,937
1979				1,928	432	0		24,621
1980		20	4,068	50,120	11,219	1		145,916
1981			1,724	15,570	3,221	16		39,121
1982			1,400	13,782	25,468	114		76,628
1983				4,252	749	10		23,028
1984		2		18,788	3,575	134		177,837
1985			519	34,540	23,511	1,165		171,070
1986				43,431	3,959	163		263,032
1987				77,652	12,494	1,426		300,760
1988				24,806	11,702	205		93,465
1989				38,624	17,656	153		156,813
1990		18		26,288	4,734	193		113,530
1991		17		46,972	6,874	300		233,651
1992		39		38,304	9,253	199		188,604
1993		36		33,189	4,859	607		264,283
1994			1,720	24,011	9,051	110		269,027
1995		22		20,728	4,135	184		201,173
1996		32	30	23,593	11,646	119		169,241
1997		17	48	36,817	5,244	141		244,803
1998				30,257	6,523	124		273,844
1999			100	22,726	2,638	87		281,984
2000		4		21,388	1,624	456		226,935
2001	0	0	320	19,432	5,249	84		217,447
2002	0	11	0	20,319	2,939	78		127,330
2003	0	0	0	14,619	508	51		151,748
2004	0	0	2,017	13,027	549	55	4	169,238

Table 7. MHI (Maui, Lanai, Molokai, and Kahoolawe) BMUS catch per trip (CPUE) with 95% confidence limits (CL). Data sources are indicated in Table 2.

Year	CPUE	Lower 95% CL	Upper 95% CL
1948	614	514	712
1949	713	626	811
1950	677	591	759
1951	621	565	682
1952	577	521	630
1953	645	557	743
1954	887	804	977
1955	755	682	831
1956	784	705	867
1957	789	707	876
1958	533	477	592
1959	519	472	565
1960	630	565	695
1961	496	444	547
1962	491	441	542
1963	518	472	560
1964	619	556	688
1965	503	466	538
1966	536	489	582
1967	602	533	678
1968	478	437	516
1969	480	431	527
1970	433	384	482
1971	433	381	488
1972	514	454	577
1973	421	376	462
1974	329	298	359
1975	430	396	466
1976	485	443	526
1977	527	463	591
1978	635	564	720
1979	380	345	418
1980	421	384	461
1981	416	378	464
1982	307	281	335
1983	214	198	233
1984	220	205	236
1985	230	209	253
1986	274	246	310
1987	237	223	251
1988	329	295	368
1989	361	330	395
1990	245	227	262
1991	202	189	215
1992	228	211	245
1993	213	196	230
1994	217	200	235
1995	193	175	210
1996	125	117	134
1997	176	164	188
1998	130	120	141
1999	209	190	228
2000	187	173	201
2001	194	179	210
2002	179	164	195
2003	190	177	204
2004	171	162	181

Table 8. Mau Zone catch per trip (CPUE) with 95% confidence limits (CL).

Year	CPUE	Lower 95% CL	Upper 95% CL
1948	5968	4015	7991
1949	6799	4981	8914
1950	4966	3336	6321
1951	4980	4181	5934
1952	7407	5378	9350
1953	8937	5838	13552
1954	6158	4424	8085
1955	4659	3493	5895
1956	2523	1676	3354
1957	3958	2842	4896
1958	0	0	0
1959	0	0	0
1960	6379	4972	7724
1961	6999	5295	8925
1962	4641	3855	5306
1963	6410	4970	7834
1964	8028	6006	10202
1965	6656	5404	7516
1966	4413	3510	5333
1967	14749	8397	26175
1968	6055	3742	9752
1969	11484	10712	12864
1970	7111	4336	8811
1971	4784	3585	6467
1972	2386	1761	3031
1973	3224	2586	4147
1974	3367	2784	4235
1975	5439	4402	6746
1976	4653	4013	5392
1977	4387	3057	5425
1978	4753	3952	5695
1979	5361	4255	6693
1980	6210	1076	13314
1981	1336	0	0
1982	0	0	0
1983	2242	1612	2871
1984	4308	2908	6266
1985	4239	3606	4820
1986	2206	1483	2983
1987	2889	2249	3529
1988	2136	1856	2386
1989	5412	3589	7210
1990	4454	3875	5135
1991	2413	1841	3297
1992	2092	1647	2714
1993	1992	1670	2354
1994	3748	2349	5294
1995	2460	1907	3059
1996	2823	2326	3414
1997	3294	2759	3911
1998	2518	2025	2948
1999	2926	2273	3689
2000	2654	1662	3743
2001	2066	1461	2698
2002	2496	2001	3042
2003	3086	2475	3816
2004	2953	2509	3439

Table 9. Ho'omalu Zone catch per trip (CPUE) with 95% confidence limits (CL).

Year	CPUE	Lower 95% CL	Upper 95% CL
1948	14635	0	0
1949	4614	0	0
1950	6072	5430	6837
1951	8228	0	0
1952	4766	2658	6901
1953	7627	6238	9581
1954	8613	7194	10075
1955	9336	7596	10920
1956	5202	0	0
1957	1535	0	0
1958	6254	5182	7033
1959	5897	5055	6739
1960	8139	7713	8616
1961	7978	0	0
1962	0	0	0
1963	0	0	0
1964	8390	0	0
1965	0	0	0
1966	0	0	0
1967	0	0	0
1968	0	0	0
1969	0	0	0
1970	0	0	0
1971	0	0	0
1972	0	0	0
1973	0	0	0
1974	0	0	0
1975	0	0	0
1976	0	0	0
1977	4000	0	0
1978	3550	0	0
1979	4951	3882	6318
1980	6687	4052	8840
1981	8167	3153	12302
1982	7953	4510	11395
1983	3025	2590	3378
1984	4085	3643	4592
1985	5909	4418	7005
1986	5301	4537	6300
1987	8187	6720	9412
1988	4702	3799	5588
1989	5328	3989	7160
1990	4793	3850	5656
1991	5928	5105	6714
1992	7388	6189	9231
1993	8040	7137	9054
1994	4651	3434	5790
1995	5544	4158	7164
1996	5870	4918	6943
1997	5234	4379	6053
1998	5198	4580	5876
1999	4606	4107	5158
2000	5212	4541	5818
2001	5300	4710	5880
2002	4651	4149	5150
2003	4483	3888	5057
2004	4272	3763	4814

Table 10. NWHI CPUE (pounds/day).

Year	Mau Zone	Ho'omalu Zone
1988	322	866
1989	677	808
1990	573	675
1991	333	671
1992	239	639
1993	267	723
1994	353	629
1995	306	582
1996	298	563
1997	429	574
1998	364	527
1999	337	534
2000	260	601
2001	283	543
2002	438	412
2003	481	488
2004	448	438

Table 11. Mean body weight (lbs) of Hawaiian bottomfish by species and management zone. Data sources are indicated in Table 2.

Opakapaka

Year	MHI	Mau	Ho'omalu
1988	3.9	10.3	10.0
1989	4.4	8.9	11.1
1990	5.1	7.1	9.3
1991	4.6	7.6	9.1
1992	4.5	6.7	8.5
1993	3.6	6.9	8.1
1994	3.9	7.5	8.7
1995	3.6	8.2	8.7
1996	3.6	8.6	8.0
1997	4.0	9.2	7.8
1998	3.3	8.7	8.0
1999	3.4	8.9	7.6
2000	3.8	8.3	8.0
2001	3.6	8.3	8.5
2002	3.8	10.8	8.8
2003	3.8	10.1	9.3
2004	3.5	6.4	9.1
Average	3.9	8.4	8.7

Ehu

Year	MHI	Mau	Ho'omalu
1988	1.7	3.8	4.5
1989	1.6	4.1	4.3
1990	1.6	3.9	4.8
1991	1.8	3.2	3.8
1992	1.7	4.1	3.9
1993	1.6	3.2	3.5
1994	1.6	2.7	3.5
1995	1.5	3.3	3.3
1996	1.7	3.0	3.4
1997	1.4	3.1	3.2
1998	2.0	3.8	3.5
1999	2.0	3.6	3.6
2000	1.8	3.3	4.3
2001	1.7	3.0	3.8
2002	1.8	3.7	3.0
2003	1.9	3.4	3.5
2004	2.2	2.6	3.6
Average	1.7	3.4	3.7

Onaga

Year	MHI	Mau	Ho'omalu
1988	5.8	11.0	10.6
1989	4.6	8.1	9.1
1990	4.9	10.2	10.3
1991	5.0	12.0	11.4
1992	5.3	12.7	9.9
1993	4.9	10.8	10.9
1994	4.1	11.9	10.0
1995	4.4	12.7	7.2
1996	3.7	12.9	9.1
1997	3.9	13.7	7.6
1998	3.9	5.4	7.7
1999	4.1	13.6	9.7
2000	4.1	7.9	8.4
2001	5.3	8.6	8.5
2002	4.9	11.4	8.4
2003	5.3	9.9	9.0
2004	5.5	8.8	9.2
Average	4.7	10.7	9.2

Uku

Year	MHI	Mau	Ho'omalu
1988	8.9	15.7	14.7
1989	8.9	14.2	15.5
1990	8.8	12.1	13.3
1991	9.7	13.6	13.4
1992	9.5	13.0	10.6
1993	9.5	12.2	10.7
1994	8.6	11.9	11.0
1995	8.6	11.3	10.3
1996	8.2	12.0	11.9
1997	8.3	12.6	10.3
1998	8.8	13.6	11.2
1999	8.3	11.5	10.1
2000	7.3	10.9	8.5
2001	8.0	11.0	9.7
2002	8.4	10.4	8.9
2003	8.6	10.6	10.7
2004	8.4	10.5	10.8
Average	8.6	12.2	11.3

Table 11 (continued). Mean body weight of Hawaiian bottomfish.

Hapu'upu'u

Year	MHI	Mau	Ho'omalu
1988	12.8	10.0	14.7
1989	12.7	14.2	12.9
1990	10.7	12.9	15.6
1991	14.6	12.8	15.4
1992	12.4	13.7	14.0
1993	7.8	12.5	13.0
1994	9.7	11.6	13.6
1995	7.1	11.8	14.0
1996	7.9	13.5	14.4
1997	8.9	13.0	14.0
1998	8.1	12.7	14.1
1999	8.4	12.7	14.4
2000	7.5	12.6	14.4
2001	11.2	13.2	15.2
2002	9.4	13.1	13.7
2003	10.2	11.7	15.0
2004	10.3	12.7	13.2
Average	10.0	12.6	14.2

Table 12. Percent of Hawaiian bottomfish catch (in weight) made up of immature fish. Data sources are indicated in Table 2.

Opakapaka

Year	MHI	Mau	Ho'omalu
1988	23.8	0.2	0.0
1989	15.1	0.0	0.0
1990	8.6	4.4	0.2
1991	12.3	5.4	2.0
1992	14.2	2.2	0.8
1993	25.8	1.4	0.1
1994	23.3	3.0	0.1
1995	26.0	2.1	0.2
1996	25.7	0.5	0.9
1997	19.0	0.4	0.9
1998	32.9	0.2	0.5
1999	26.3	0.3	0.7
2000	21.5	0.0	0.4
2001	23.7	1.7	0.2
2002	19.6	0.2	1.2
2003	20.7	0.8	0.4
2004	27.6	8.1	0.3
Average	21.5	1.8	0.5

Ehu

Year	MHI	Mau	Ho'omalu
1988	13.0	0.0	0.0
1989	14.0	0.1	0.0
1990	14.9	0.1	0.0
1991	8.3	0.5	0.0
1992	9.3	0.0	0.1
1993	8.6	0.2	0.0
1994	12.1	2.1	0.3
1995	13.0	0.6	0.8
1996	9.4	0.1	0.6
1997	14.6	0.1	0.8
1998	4.5	0.0	0.4
1999	5.7	0.0	0.2
2000	7.2	0.0	0.1
2001	10.0	0.5	0.2
2002	8.3	0.1	0.0
2003	7.8	0.0	0.2
2004	4.0	2.9	0.1
Average	9.7	0.4	0.2

Onaga

Year	MHI	Mau	Ho'omalu
1988	54.5	25.4	23.9
1989	71.3	47.2	42.6
1990	71.9	35.8	39.9
1991	75.6	24.6	27.9
1992	73.1	22.4	44.1
1993	66.1	18.9	31.9
1994	68.5	11.5	28.9
1995	73.7	11.9	44.1
1996	80.5	8.6	33.3
1997	80.9	8.0	63.4
1998	77.6	54.3	57.3
1999	82.5	7.7	9.7
2000	83.6	48.9	48.5
2001	88.3	44.5	47.9
2002	85.1	18.0	51.1
2003	77.6	28.0	49.0
2004	74.4	29.7	43.0
Average	75.6	26.2	40.4

Uku

Year	MHI	Mau	Ho'omalu
1988	1.0	0.0	0.0
1989	8.0	0.0	0.0
1990	1.4	0.1	0.0
1991	0.5	0.1	0.0
1992	0.3	0.0	0.0
1993	0.7	0.1	0.0
1994	0.8	0.1	0.0
1995	0.9	0.1	0.1
1996	1.5	0.0	0.0
1997	2.5	0.2	0.0
1998	1.3	0.0	0.0
1999	0.6	0.2	0.1
2000	1.7	0.1	0.1
2001	3.4	0.0	0.0
2002	0.6	0.2	0.0
2003	0.7	0.0	0.0
2004	2.2	0.0	0.0
Average	1.7	0.1	0.0

Table 12 (continued). Percent of Hawaiian bottomfish catch (in weight) made up of immature fish. Data sources are indicated in Table 2.

Hapu'upu'u			
Year	MHI	Mau	Ho'omalu
1988	12.4	24.9	14.7
1989	10.6	9.5	12.6
1990	15.8	7.8	7.0
1991	6.0	9.3	6.3
1992	10.5	7.0	6.2
1993	32.1	9.0	8.5
1994	16.9	12.8	9.9
1995	39.1	13.6	9.5
1996	35.0	10.5	8.3
1997	26.1	11.2	9.4
1998	31.9	14.3	7.9
1999	28.8	10.6	6.6
2000	28.5	11.7	7.8
2001	15.4	9.9	5.6
2002	20.8	10.4	9.0
2003	16.4	14.5	6.8
2004	18.1	12.0	11.5
Average	21.4	11.7	8.7

Table 13. Archipelagic SPR.

Year	Opakapaka	Onaga	Ehu	Uku	Hapu'upu'u
1986	51	53	41	58	55
1987	69	61	61	65	71
1988	49	42	37	62	56
1989	69	38	51	68	70
1990	57	36	44	52	57
1991	57	42	44	53	58
1992	68	41	51	61	67
1993	67	53	54	73	65
1994	53	39	38	52	51
1995	54	33	41	56	48
1996	52	39	43	57	49
1997	52	25	42	51	49
1998	47	22	38	50	44
1999	46	34	37	55	47
2000	52	27	39	52	49
2001	51	26	40	48	51
2002	47	26	37	45	45
2003	48	28	36	42	47
2004	43	28	36	42	44

Table 14. Dynamic production model specifications for the current stock assessment.

Archipelagic Reference Values for Dynamic Production Model Parameters			
Model Parameter	**Reference Value**		
Carrying Capacity (k) [lbs]	7,131,473		
B_{MSY} [lbs]	3,565,736		
MSY [lbs]	811,225		
Zonal Model Outputs and Metrics			
Model Output/Metric	**MHI**	**Mau**	**Ho'omalu**
Catchability (q) [per day]	Period / q value: < 1961 — 0.000166; 1961–1984 — 0.000190; 1985–1991 — 0.000238; 1992–present — 0.000285	0.000991	0.000262
Intrinsic Rate of Population Increase (r)	0.455011	0.455011	0.455011
Zonal Carrying Capacity Contribution [lbs]	3,186,215	882,608	3,062,650
Zonal MSY Contribution (ZMC) [lbs]	362,441	100,399	348,385
Biomass at ZMC [lbs]	1,593,107	441,304	1,531,325
$CPUE_{ZMC}$ [lbs per day]	405	437	400
E_{ZMC} [days]	895	230	870
Zonal Weighting Factors (proportion of archipelagic 100 fathom contour)	0.447	0.124	0.429

Table 15. Biomass and fishing mortality metrics ($B_metric_{<zone>}$ and $F_metric_{<zone>}$) for the Hawaiian bottomfish management zones. Estimates in shaded area are hindcasts for the period before the biomass and fishing Mortality Control Rule was adopted. If $B_metric_{<zone>} < 0.7$ localized depletion has occurred; if $F_metric_{<zone>} > 1.0$ excessive fishing pressure is occurring.

	Biomass Metric			Fishing Mortality Metric		
Year	MHI	Mau	Ho'omalu	MHI	Mau	Ho'omalu
1988	0.81	0.74	2.16	3.53	0.54	0.78
1989	0.89	1.55	2.02	2.72	0.76	0.26
1990	0.60	1.31	1.69	2.46	1.89	0.29
1991	0.50	0.76	1.68	2.46	1.35	0.49
1992	0.56	0.55	1.60	2.35	1.29	0.64
1993	0.53	0.61	1.81	1.94	1.60	0.46
1994	0.54	0.81	1.57	2.20	1.97	0.52
1995	0.48	0.70	1.45	2.55	2.37	0.40
1996	0.31	0.68	1.41	3.36	1.94	0.36
1997	0.43	0.98	1.43	2.54	1.07	0.48
1998	0.32	0.83	1.32	3.23	0.79	0.58
1999	0.52	0.77	1.33	1.97	0.70	0.58
2000	0.46	0.59	1.50	2.52	0.82	0.41
2001	0.48	0.65	1.36	1.74	0.77	0.50
2002	0.44	1.00	1.03	1.95	1.07	0.34
2003	0.47	1.10	1.22	1.74	0.86	0.35
2004	0.42	1.02	1.09	2.11	0.88	0.40

Table 16. Biomass and fishing mortality stock status values for bottomfish in the Hawaiian Archipelago are used to determine stock status under the current Control Rule. Estimates in shaded area are hindcasts for the period before the Control Rule was adopted. If $B_{status} < 0.7$ the stock is overfished; if $F_{status} > 1.0$ overfishing is occurring.

Year	B_{status}	F_{status}
1988	1.38	1.98
1989	1.46	1.42
1990	1.16	1.46
1991	1.04	1.48
1992	1.00	1.48
1993	1.09	1.26
1994	1.01	1.45
1995	0.92	1.61
1996	0.83	1.90
1997	0.93	1.48
1998	0.81	1.79
1999	0.90	1.21
2000	0.92	1.40
2001	0.88	1.09
2002	0.76	1.15
2003	0.87	1.03
2004	0.79	1.22

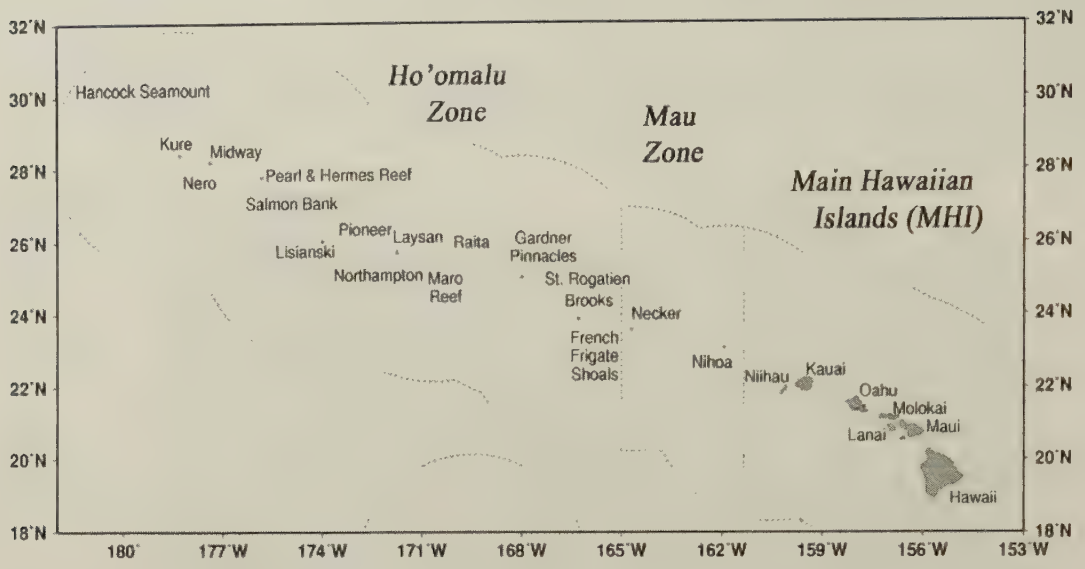

Figure 1. Map of the Hawaiian Archipelago with bottomfish management zones.

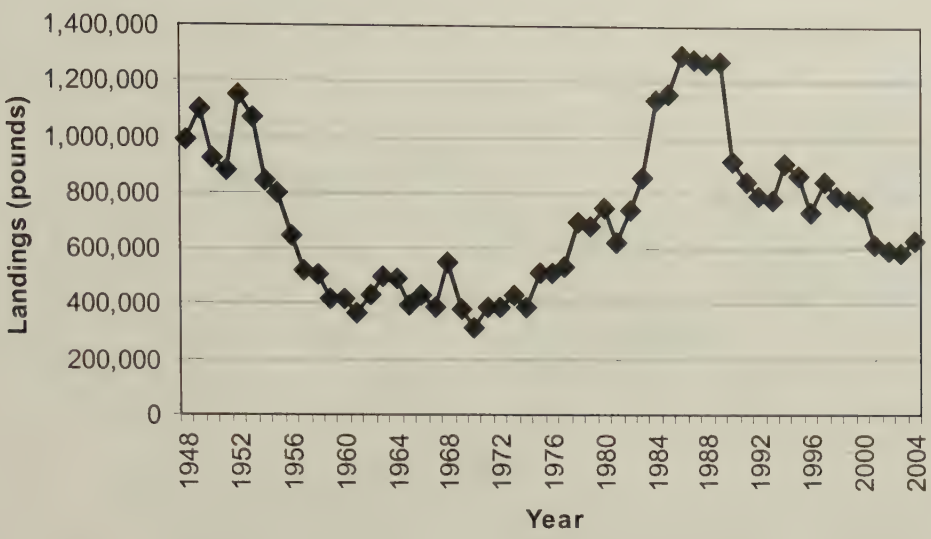

Figure 2a. Total adjusted BMUS landings for the Hawaiian Archipelago.

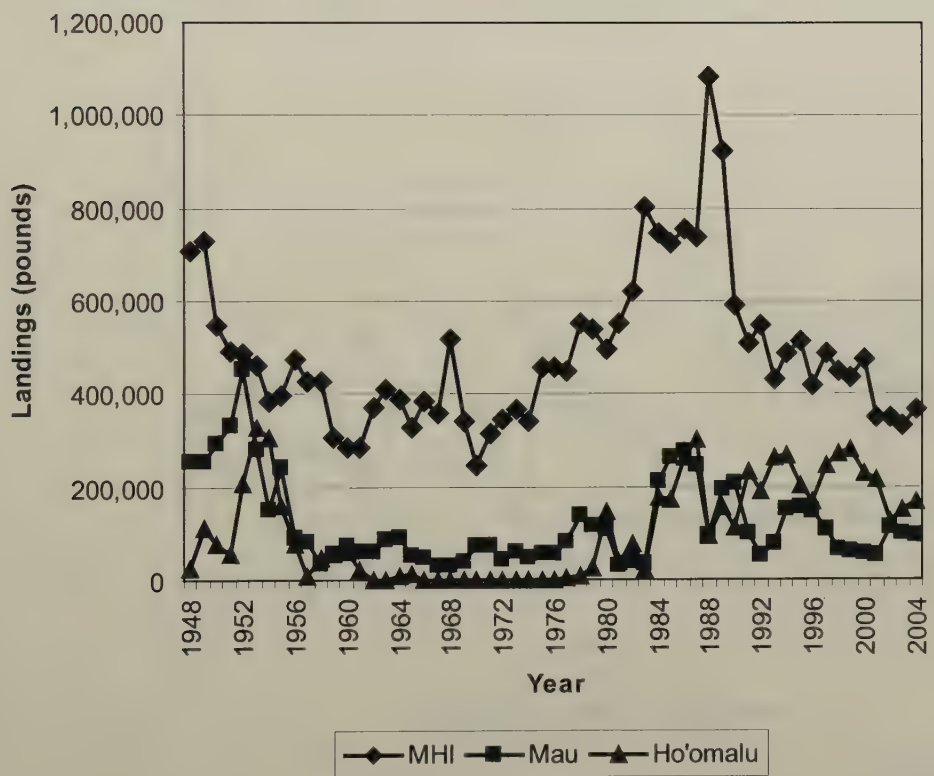

Figure 2b. Total adjusted BMUS landings by management zone.

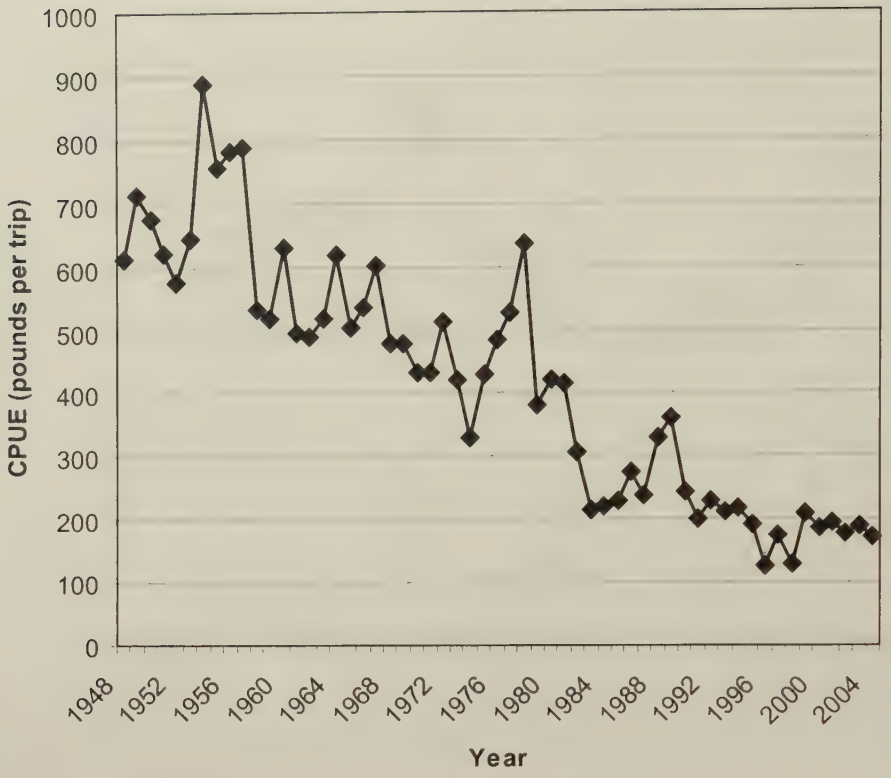

Figure 3. MHI catch per trip (CPUE) by year.

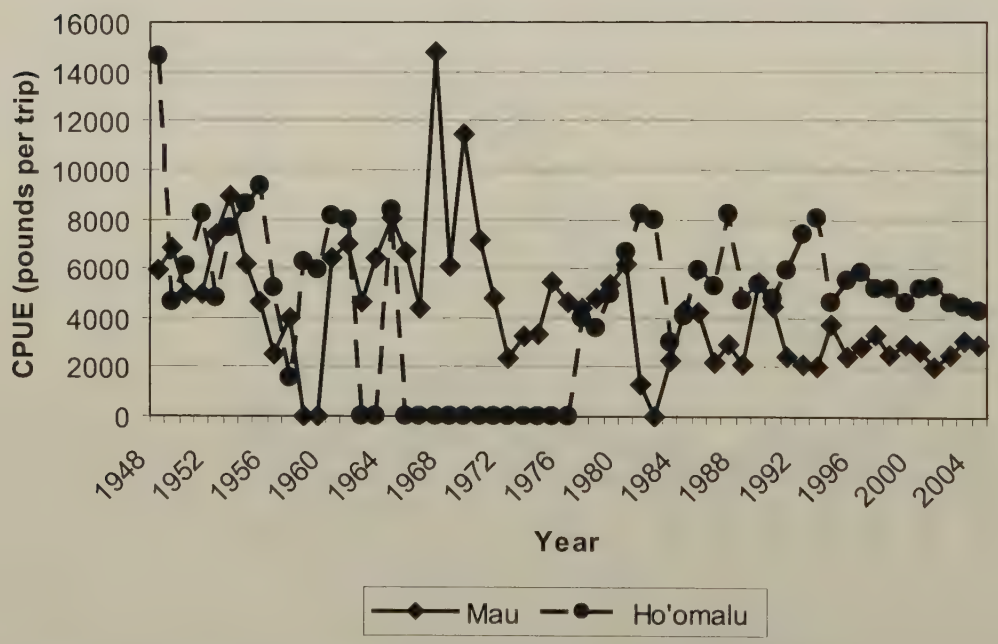

Figure 4. NWHI catch per trip (CPUE) by year.

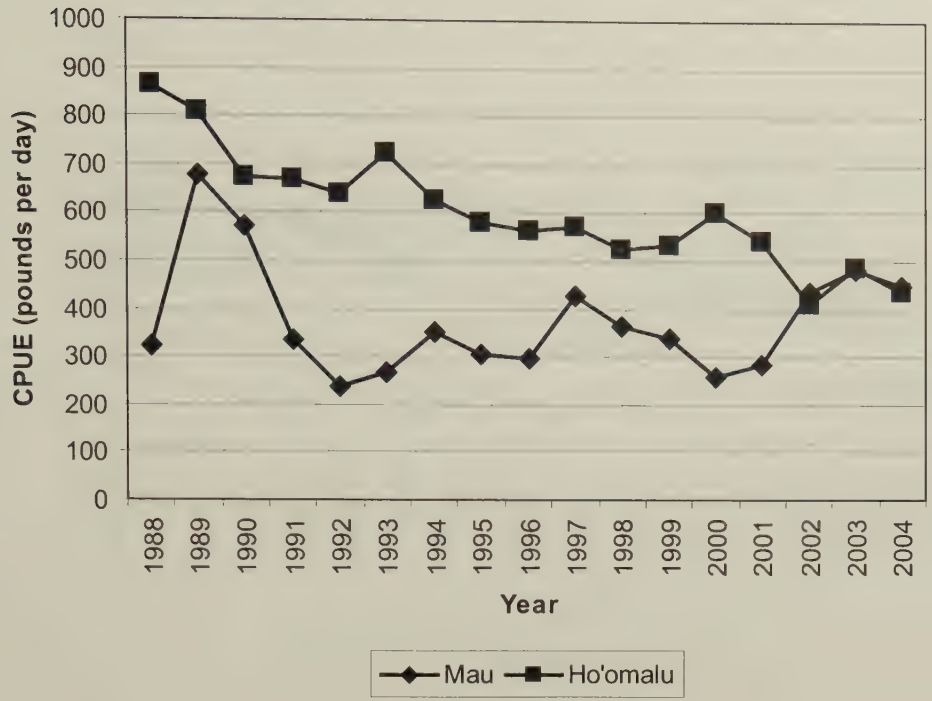

Figure 5. NWHI catch per day (CPUE) by year

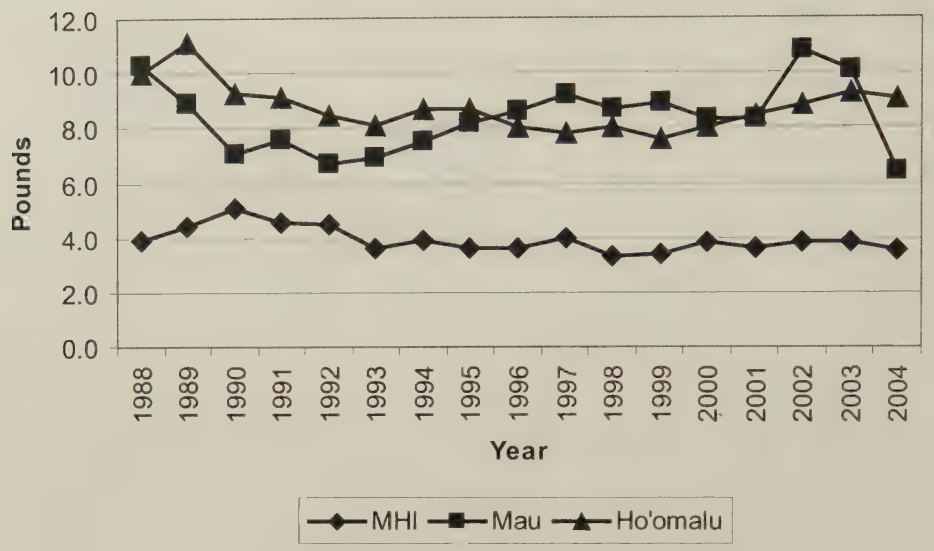

Figure 6a. Mean body weight by year and management zone — OPAKAPAKA.

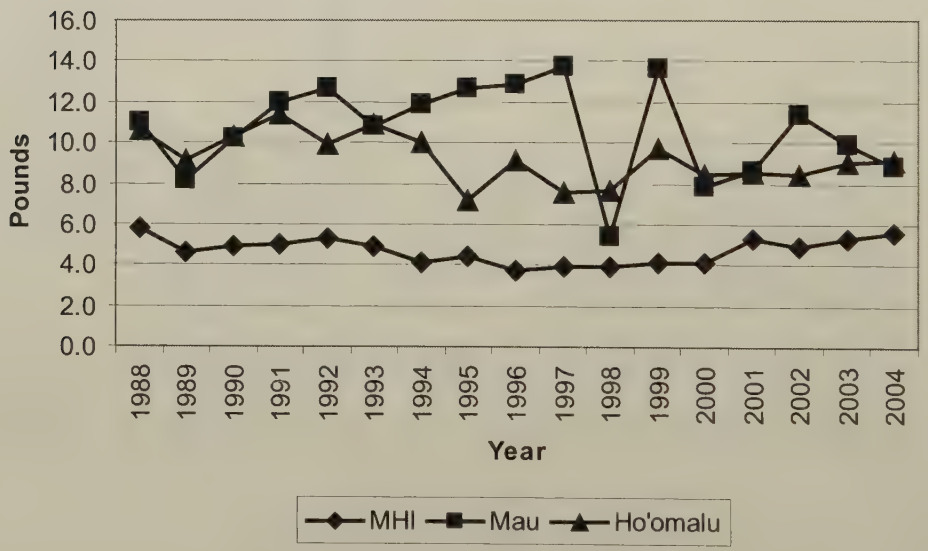

Figure 6b. Mean body weight by year and management zone — ONAGA.

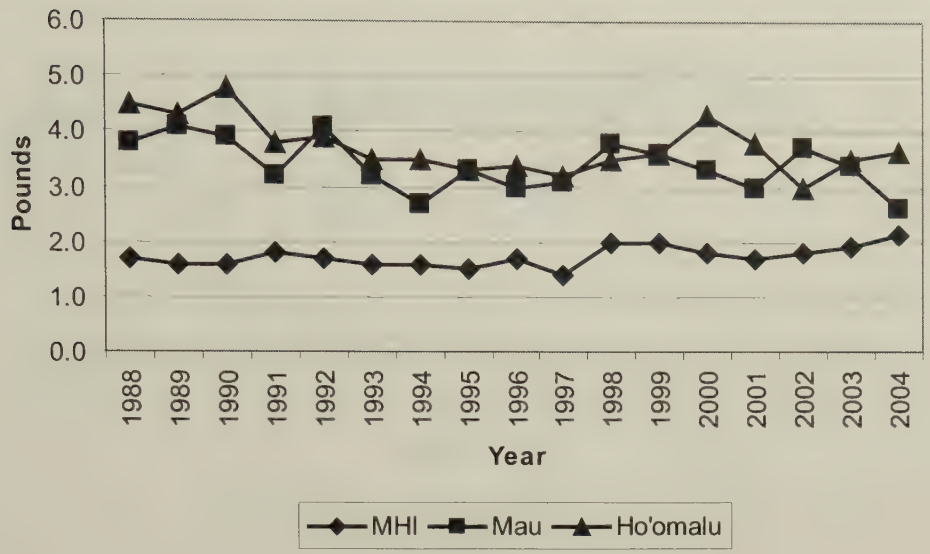

Figure 6c. Mean body weight by year and management zone — EHU.

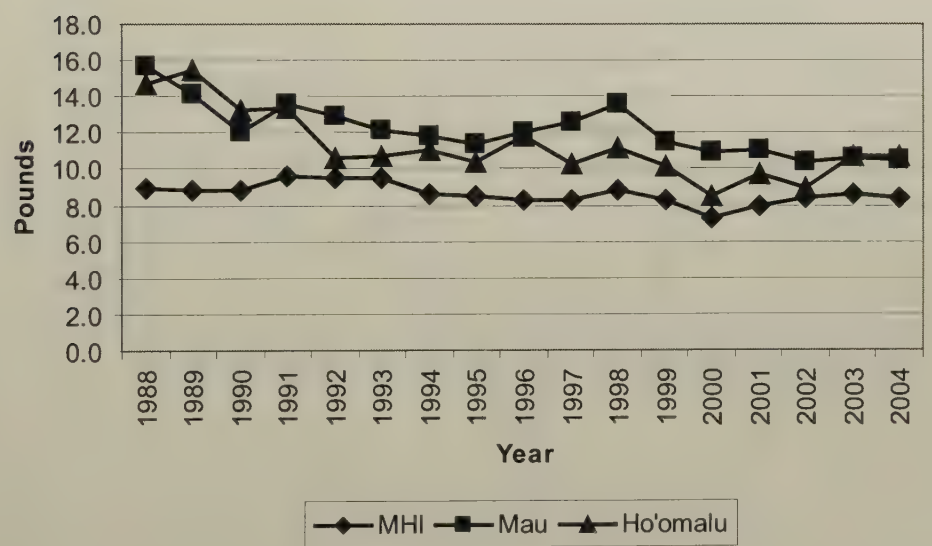

Figure 6d. Mean body weight by year and management zone — UKU.

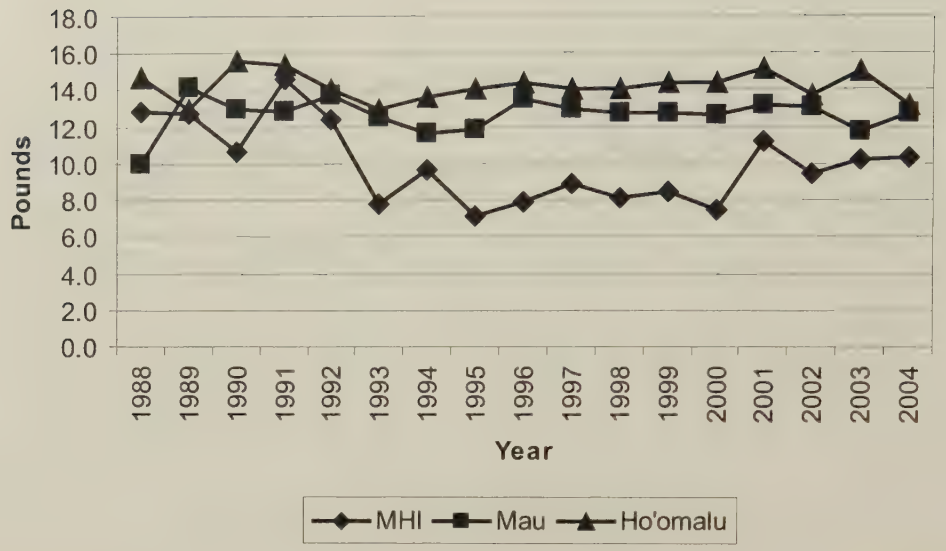

Figure 6e. Mean body weight by year and management zone — HAPU'UPU'U.

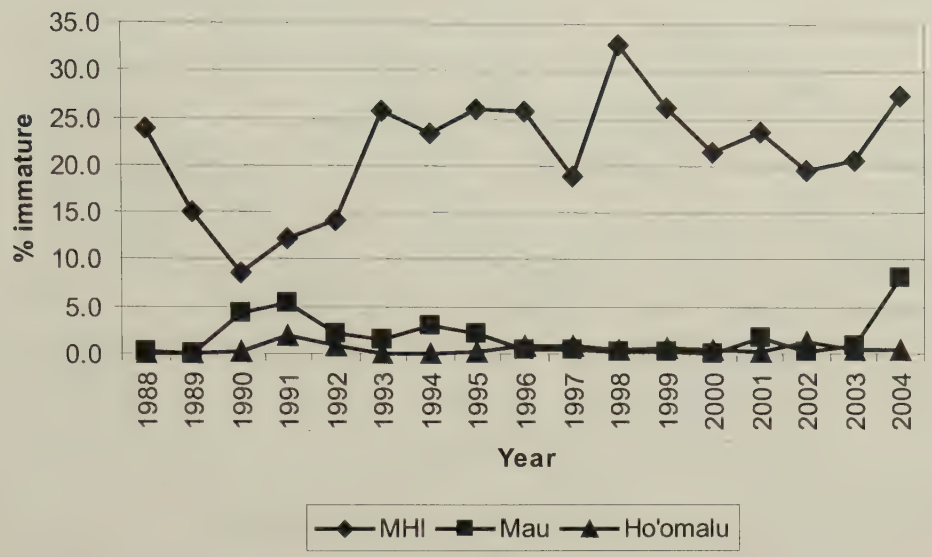

Figure 7a. Percent of catch (in weight) made up of immature fish — OPAKAPAKA.

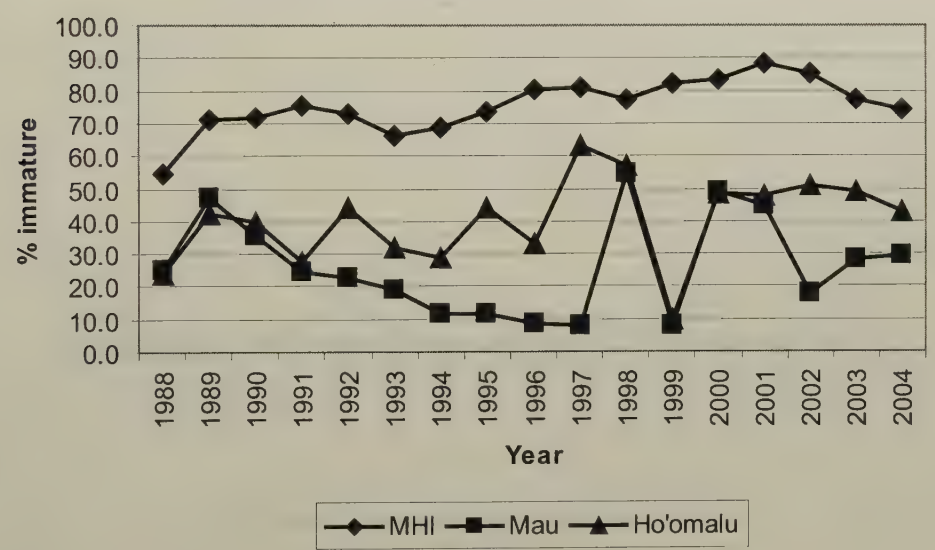

Figure 7b. Percent of catch (in weight) made up of immature fish — ONAGA.

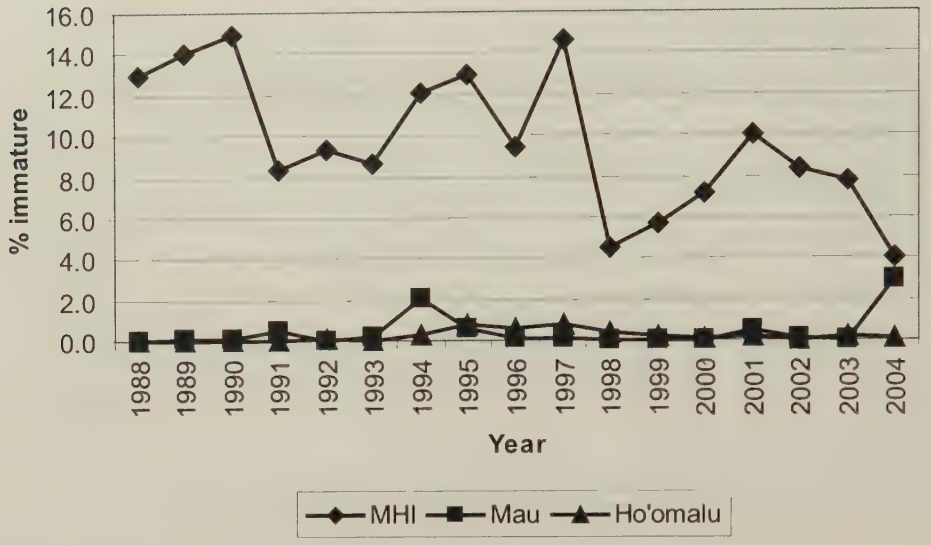

Figure 7c. Percent of catch (in weight) made up of immature fish — EHU.

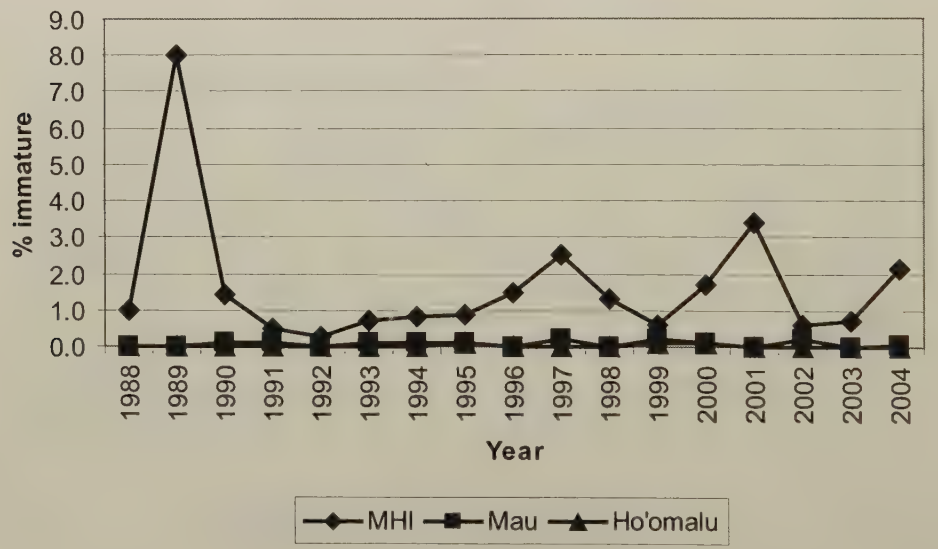

Figure 7d. Percent of catch (in weight) made up of immature fish — UKU.

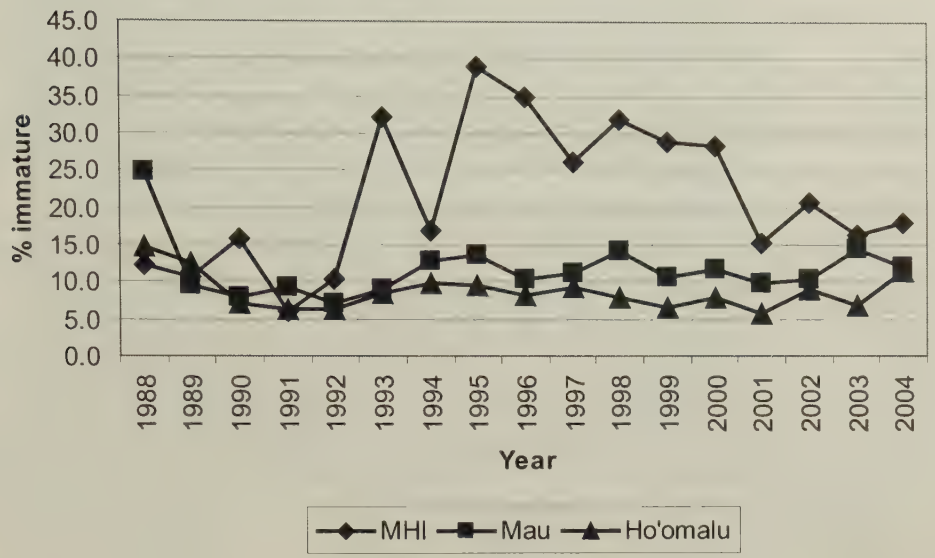

Figure 7e. Percent of catch (in weight) made up of immature fish — HAPU'UPU'U.

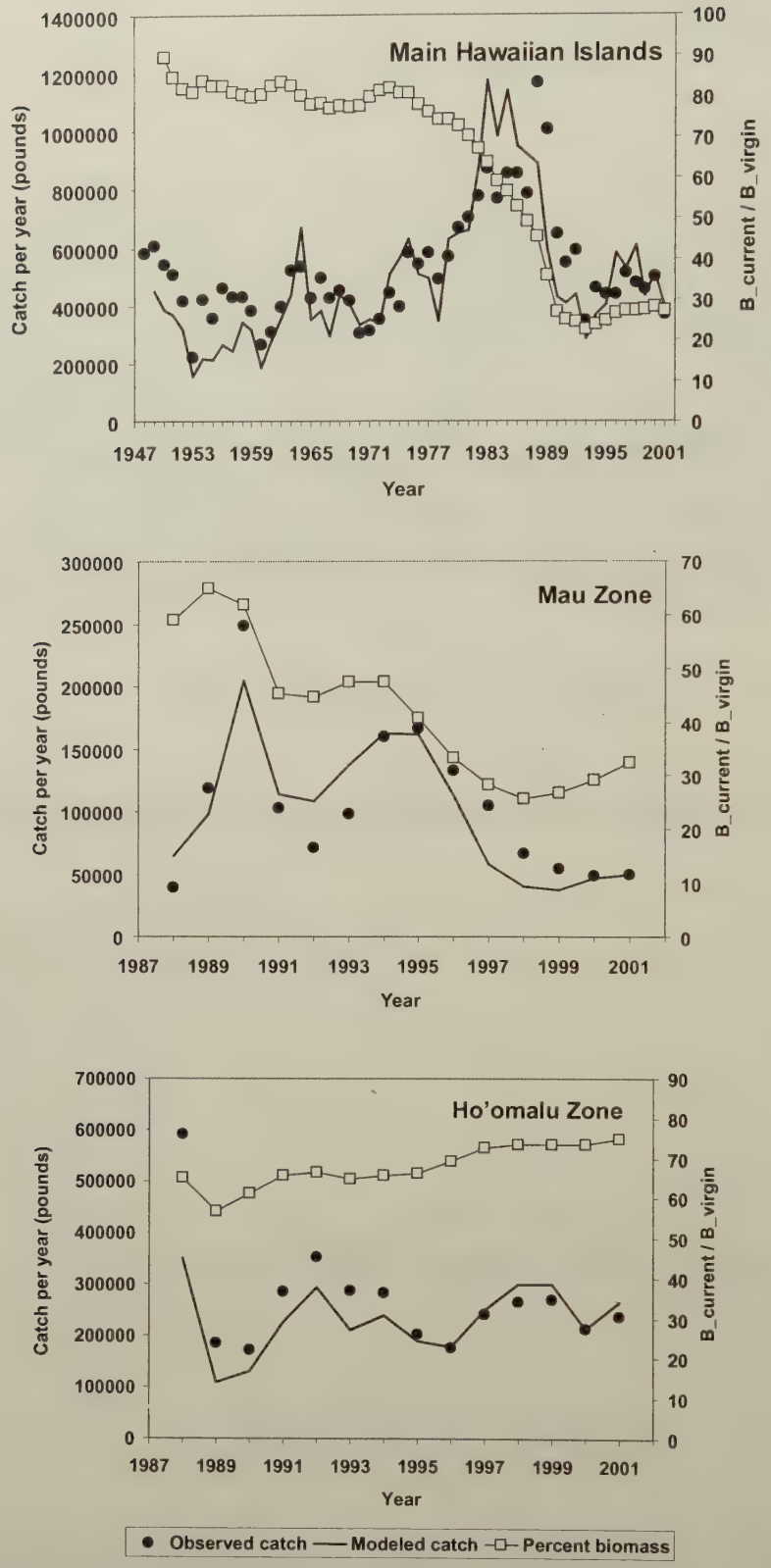

Figure 8. Trajectories of observed catch, modeled catch, and modeled percent of virgin (initial) biomass for aggregate bottomfish stocks in the Hawaiian Archipelago bottomfish management zones.

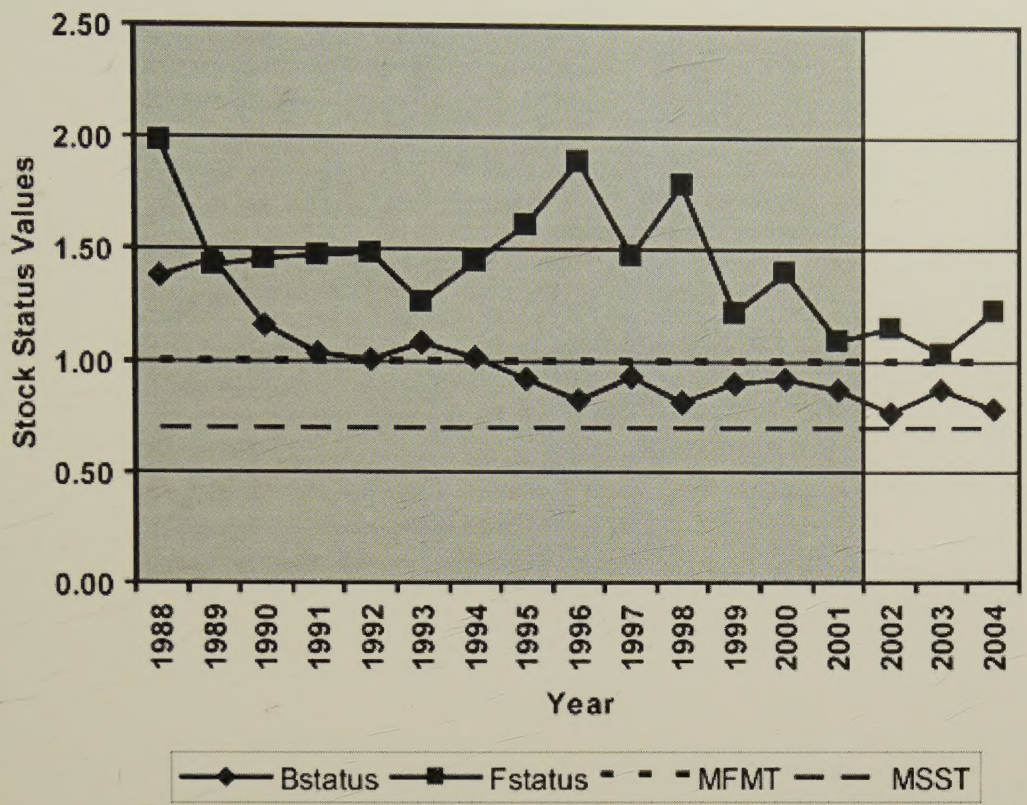

Figure 9. Trajectories of biomass and fishing mortality stock status values relative to established reference points for Hawaiian Archipelago bottomfish. Values in shaded areas are for time period before adoption of current Control Rule. Heavy dotted line is MFMT (1.0) and heavy dashed line is MSST (0.7).